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ABSTRACT

Twelve PLATO lessons are reproduced in this document to show the status of computer guided experimentation (CGE) instructional programs. The lesson topics include a description of the CGE-PLATO instructional laboratory, an introduction to CGE-PLATO tests and special software routines, router lesson for two electrical engineering courses, and an introduction to the CGE station. Lesson five is the operation and uses of the oscilloscope Analab 1120, and lesson six concerns the operation and uses of the audio oscillator, HP 200AB. Lessons seven, eight, and nine introduce the operation and use of the function generator Exact 251; the D.C. supply, Harrison 865B; and the vaccuum tube voltmeter, HP400D. Lesson ten is an experiment in the measurement of transients, lesson eleven is an experiment in measurements of impedance, and lesson twelve is an experiment in measurement of two-port networks. (CH)

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THE CGE—PLATO ELECTRONIC LABORATORY INSTRUCTIONAL PROGRAMS

J.P.Neal

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EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

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THE CGE-PLATO ELECTRONIC LABORATORY INSTRUCTIONAL PROGRAMS

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ABSTRACT

The twelve PLATO Lessons reproduced as Varian Prints in this report show the status of the CGE Instructional Programs as of August, 1974. This MTC Report supplements MTC Report #4, "The CGE-PLATO Electronic Laboratory Station Structure and Operation," and MTC Report #5, "Electronic Laboratory Instruction Using the CGE-PLATO Laboratory Station."

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```
    block 1a,  cgeid

stop
****    For Neal, CGERL, Room 248 EEB.

One line description of this lesson --

   A Description of the CGE-PLATO Instructional Laboratory.

             Divisions of this Lesson:        Block    Unit

           Log of users of this lesson        cgeid    cgeida
           Description of cge                 cgem0a   cgem0a
           Recent userlog                     userlog
           Common for log of users of cge     uselog

           Final edit 26 aug 74 neal.

*list   info
*list   symbols
*list   varian,charset,cgeindex,cgechar
*********
start
ext     0
dataon
area    cge
course  n70
jump    n70='eecge',cgem0a,x
***

unit    cgeida              $$ logs all noncge users into uselog
common  cge,uselog,322
jump    nc2>315,cgem0a,x
calcs   nc1='cgedata',nc1⇐'cgedata','cgedata'+0(nc2⇐4)
name    nc(nc2)
calc    nc(nc2)⇐nc(nc2)+o55
calc    nc(nc2⇐nc2+1)⇐n70+o55
date    nc(nc2⇐nc2+1)
calc    nc(nc2⇐nc2+1)⇐(int(station÷320)+27)8^10
calc    nc(nc2⇐nc2+1)⇐nc(nc2⇐nc2+1)+(frac(int(station/32)/10)×10+27)8^8
calc    nc(nc2⇐nc2+1)⇐nc(nc2⇐nc2+1)+(o46)8^6
calc    nc(nc2)⇐nc(nc2)+(int(frac(v3⇐station÷32)×3.2)+27)8^4
calc    nc(nc2)⇐nc(nc2)+(frac((frac(v3⇐station÷32)×3.2))×10+27)8^2+o55
        nc2⇐nc2+2
jump    cgem0a
***

unit    cgeidb              $$ provides jumpout to sample
term    sample
at      1613
write   One moment please.....  returning to SAMPLE.
```

```
inhibit jumpchk
jumpout sample
next    cgeidb

----------------------------------------------------------------- part=1, block=b ----------


      block 1b,  cgem0a

unit    cgem0a
base
next    cgem0b
at      205
write   A Description of the CGE-PLATO Instructional Laboratory
             in CGERL, Room 248 EEB, University of Illinois


           As outlined herein, Computer-Guided Experimentation
        (CGE) instructional experiments are designed for use at
        a special CGE-PLATO laboratory station which has a CGE
        hardware interface linking sensors on adjacent electronic
        laboratory equipment with the PLATO console.

           For an operational demonstration of CGE, contact:

                Dr. J. P. Neal, Prof. Emeritus
                Department of Electrical Engineering
                University of Illinois,
                Urbana, Illinois  61801

                217-333-4351 or 333-3496 or 344-6116

           Or come visit the CGE Research Laboratory (CGERL) at:

        Room 248 EEB, University of Illinois, Urbana, Ill.


                          Press -NEXT- to proceed.
----------------------------------------------------------------- part=1, block=c ----------


      block 1c,  cgem0b

unit    cgem0b
back    cgem0a
next    cgem0c
at      804
write      The object of this CGE-PLATO research is to demonstrate
        that the Computer-Guided Experimentation-PLATO system will
        provide unique and worthwhile improvements in undergraduate
        or technician laboratory instruction, when properly used
```

```
         by competent instructors.

            The CGE station consists of a PLATO IV console, a
         CGE-PLATO Interface Logic System, five rack-mounted
         electronic instruments, and various experimentation
         circuit boards for student use in learning electronic
         instrumentation and measurements.

            Students presently active in CGE Research are:

              Borth, David E.
              Derrig, Daniel P.
              Zanter, Douglas L.
***

unit     cgem0c
back     cgem0b
next     cgem0d
at       504
write       The CGE-PLATO Interface Logic System enables any author
         to order the automatic sensing of the interconnections
         between 30 terminals on the rack-mounted equipment or on
         the currently-used circuit board and/or the settings of
         22 of the dials, knobs, or switches on the equipment.

            The panel layout of the present CGE station is
         illustrated in the next display.  The present CGE
         rack-mounted instruments are:

            Analab Dual-trace Scope Type 1120 and Plug-In Type 700
            Exact Function Generator Type 251
            Hewlett-Packard Audio Oscillator Model 200AB
            HP Vacuum Tube Voltmeter Model 400D
            Harrison Lab. Model 865B Power Supply

            The CGE-PLATO Interface Logic System is mounted behind
         the instrument rack panel, beneath the Function Generator.

            On the next display, the automatically-sensed terminals
         may be identified by T numbers, and the automatically-
         sensed dials may be identified by D numbers.
------------------------------------------------------------------- part=1, block=d ----------


      block 1d, cgem0d


unit     cgem0d
back     cgem0c
define   panel
         switch=1
         trmnl=2
         ground=3
         dcsw=4
         solid=5
```

```
char    trmnl
        o000016,o000033,o000021,o000033,o000016,o000000,o000000,o000000
char    switch
        o000000,o000340,o000760,o001777,o001777,o000760,o000340,o000000
char    ground
        o000000,o100000,o120000,o124000,o124000,o120000,o100000,o000000
char    dcsw
        o000600,o000600,o000600,o000600,o001700,o003740,o003740,o001700
char    solid
        o177777,o177777,o177777,o177777,o177777,o177777,o177777,o177777
draw    509,133;0,133
zero    n5
zero    n6
calc    n7⇐1314
join    cges1a
join    cges1b
addl    n5
calc    n7⇐1534
join    cges1a
join    cges1c
addl    n5
calc    n7⇐1552
join    cges1a
join    cges1d
addl    n5
calc    n7⇐2212
join    cges1a
join    cges1e
addl    n5
calc    n7⇐2243
join    cges1a
join    cges1f
addl    n5
join    cges1a
join    cges1g
at      3117
write     Press -LAB-  for sensed dials.
        Press -DATA- for sensed terminals.

entry   cgem0de
pause
calc    n1⇐(key=next$or$key=back) - (key=lab) -2 (key=data)
join    n1,x,x,cges2a,cges3a,x
jump    (key=next) - (key=back) ,cgem0e,x,cgem0c
goto    key=o216,x,cgem0de,x
press   o216
***

--------------------------------------------------------------- part=1, block=e ----------


      block 1e,   cgem0e


unit    cgem0e
back    cgem0d
```

```
next     cgem0f
at       705
write       Actual laboratory experiments are programmmed by
         experienced laboratory instructors on the PLATO system.

            The instructor writing a program provides for the
         automatic sensing of terminal interconnections and/or
         dial settings wherever he deems necessary.

            The response of the program to the fedback information
         of the student's physical operations can be used in any
         manner the instructor devises for improving the student's
         learning.

            Each student can work independently at a CGE station
         and learn at his own rate how to use the equipment,
         and perform or devise meaningful experiments.
***

unit     cgem0f
back     cgem0e
next     cgem0g
at       903
write       CGE is an entirely new instructional system, and
         research is required to develop its teaching capabilities
         and demonstrate their superiorities in comparison with
         conventional laboratory instruction or training simulators.


            CGE is not simply a new Teaching Aid, it is a New Teaching
         Method with unexplored and unknown capabilities.


            The manner in which a student at a CGE station in a
         laboratory is provided ready access to laboratory facilities,
         theoretical material, computer assistance, and
         instructor assistance is visualized in the next display.
------------------------------------------------------------ part=1, block=f ---------


      block 1f.  cgem0g


unit     cgem0g
back     cgem0f
next     cgem0h
calc     n1⇐.5
circle   129,256,360
at       427
write      Student
              in
           Laboratory
delay    n1
circle   129,256,144
at       2626
```

```
write        Student
               in
          Theory Course
delay     n1
circle    128,320,256
at        1746
write     Instructor
delay     n1÷2
at        2238
write     Instructor
             Aid
at        1038
write     Instructor
             Aid
delay     n1
circle    128,192,256
at        1711
write     Computer
delay     n1÷2
at        2219
write     Computer
            Aid
at        1019
write     Computer
            Aid
delay     n1÷2
at        244,192
write     CAI
delay     n1÷2
at        244,304
write     CGE
delay     n1÷2
size      1
at        212,249
write     CGE Station
delay     n1÷2
size      0
mode      rewrite
at        3007
write          The CGE Station provides the student with complete
          access to Computer Aid and Instructor Aid for both lab-
          oratory and theoretical learning.
mode      write

------------------------------------------------------------ part=1, block=g ----------


     block 1g,  cgem0h


unit      cgem0h
back      cgem0g
next      cgem0i
at        204
write        All the PLATO lessons used by CGE are open for inspection
          by authors.  These lessons are:
```

```
        CGE-PLATO          TOPIC
         LESSON

        cge       A Description of the CGE-PLATO Instructional Lab.
        cgerl     CGE-PLATO Tests & Special Software Routines
        ee244     Student List for CGERL Course
        eecge     Author List for CGERL Course
        cgeindex  Router Lesson for Courses ee244 and eecge
        cgedata   Data File for courses ee244 and eecge
        eex00     An Introduction to the CGE Station
        eex01     The Oscilloscope
        eex02     The Audio Oscillator
        eex03     The Function Generator
        eex04     The,Constant Voltage/Constant Current Supply
        eex05     The Vacuum Tube Voltmeter
        eex06     Measurements of Transients
        eex07     Measurements of Impedance
        eex08     Measurements of Two-Port Networks

           Note:  Authors in the student mode can press -MICRO-
        to pass OK through a check. Students cannot do this.

           MTC Report #4, July 1974, CERL, is entitled
        "The CGE-PLATO Electronic Laboratory Station Structure
        and Operation", by J. P. Neal.
***

unit    cgem0i
back    cgem0b
next    cgeend
at      707
write   To review this Description of CGE-PLATO, press -BACK-.


        To access the CGE Experiments, press -NEXT-.

-------------------------------------------------------------- part=1, block=h ---------


     block 1h,  cgesla


unit    cgesla
at      n6
mode    erase
writec  n5-1,,Dual-Trace SCOPE,Audio Oscillator,VTVM,
        Function Generator,DC Supply,,
calc    n6⇐n7
at      n7
mode    write
writec  n5,,Dual-Trace SCOPE,Audio Oscillator,VTVM,
        Function Generator,DC Supply,,
***

unit    cges1b
```

```
301  draw     606;635;1235;1206;606
302  circle   35,103,369
303  circle   3,55,366
304  circle   6,55,396
305  circle   6,55,336
306  circle   6,149,336
307  at       146,360
308  plot     switch
309  at       165,327
310  plot     trmnl
311  at       165,335
312  plot     trmnl
313  at       179,327
314  plot     trmnl
315  at       191,327
316  plot     trmnl
317  at       260,327
318  plot     trmnl
319  at       248,327
320  plot     trmnl
321  at       236,327
322  plot     trmnl
323  at       260,335
324  plot     trmnl
325  circle   6,149,396
326  circle   3,181,392
327  circle   10,181,392
328  circle   3,213,392
329  circle   10,213,392
330  circle   3,245,392
331  circle   10,245,392
332  circle   6,255,352
333  circle   6,227,352
334  circle   6,199,352
335  circle   6,171,352
336  ***

337  unit     cges1c
338  draw     637;647;1447;1437;637
339  circle   13,328,368
340  circle   35,328,368
341  circle   5,328,329
342  circle   10,353,311
343  circle   10,304,311
344  at       327,294
345  plot     trmnl
346  at       337,294
347  plot     trmnl
348  at       317,294
349  plot     trmnl
350  at       358,400
351  plot     switch
352  ***

353  unit     cges1d
354  draw     649;659;1459;1449;649;skip;394,404;453,404;453,364;394,364;394,404
355  circle   44,424,334,135,46
```

```
draw    415,377;408,396
circle  13,424,327
at      452,339
plot    switch
at      452,309
plot    trmnl
at      452,295
plot    trmnl
at      393,295
plot    trmnl
at      393,309
plot    trmnl
***

unit    cgesle
draw    1606;1635;2135;2106;1606
circle  8,160,217
circle  25,160,217
circle  4,184,199
circle  10,224,227
circle  6,224,227
at      256,245
plot    trmnl
at      256,235
plot    trmnl
at      256,225
plot    trmnl
at      256,215
plot    trmnl
at      256,185
plot    trmnl
at      240,185
plot    trmnl
at      222,185
plot    trmnl
circle  5,201,185
circle  8,115,230
circle  8,83,230
at      51,237
plot    trmnl
at      51,227
plot    trmnl
at      51,217
plot    trmnl
at      88,188
plot    switch
***

unit    cges1f
draw    2141;1841;1853;2153;2141
draw    357,218;325,218;325,194;357,194;357,218
circle  6,401,194
circle  6,401,213
circle  6,376,203
at      393,181
plot    trmnl
at      381,181
```

```
plot    trmnl
at      369,181
plot    trmnl
at      329,177
plot    ucsw
----------------------------------------------------------- part=1, block=i -----------


     block 1i,   cges1g


unit    cges1g
at      2810
write   Location behind the panel of the complete and
        operable CGE-PLATO Interface Logic System
draw    272,171;40,171;40,138;272,138;272,171
draw    143,155;143,151;160,151;160,155;143,155
draw    248,78;194,132;skip;194,132;skip;192,134;178,148
        178,144;182,148;178,148
at      46,165
plot    trmnl
at      55,165
plot    trmnl
pause
mode    erase
draw    248,78;194,132;skip;194,132;skip;192,134;178,148
        178,144;182,148;178,148
draw    272,171;40,171;40,138;272,138;272,171
draw    143,155;143,151;160,151;160,155;143,155
at      46,165
plot    trmnl
at      55,165
plot    trmnl
at      2810
write   Location behind the panel of the complete and
        operable CGE-PLATO Interface Logic System
mode    write
----------------------------------------------------------- part=1, block=j -----------


     block 1j,   cges2a


unit    cges2a
join    cges2b
join    cges2c
join    cges2d
join    cges2e
join    cges2f
***

unit    cges2b
draw    50,339;22,345
```

```
at      1101
write   D8
draw    243,397;243,427
at      227,427
write    D1
draw    211,397;211,427
at      195,427
write    D2
draw    179,397;179,427
at      163,427
write    D3
draw    169,352;153,442
at      137,442
write    D7
draw    197,352;191,442
at      175,442
write    D6
draw    226,352;226,452
at      210,452
write    D5
draw    254,352;270,452
at      254,452
write    D4
draw    146,333;127,310
at      111,290
write    D9
***

unit    cges2c
at      146,261
write   D12
draw    162,231;162,261
draw    224,227;240,267
at      224,267
write   D14
draw    218,237;202,277
at      186,277
write   D13
draw    198,180;182,160
at      166,140
write   D15
draw    81,237;81,267
at      65,267
write   D10
draw    113,237;113,267
at      97,267
write   D11
***

unit    cges2d
draw    353,304;370,283
at      354,263
write    D19
draw    300,303;292,279
at      276,259
write   D20
draw    327,386;327,436
```

```
at       311,436
write     D21
***

unit     cges2e
draw     425,333;474,378
at       474,368
write    D22
***

unit     cges2f
draw     374,204;374,234
at       358,234
write     D16
draw     399,214;415,234
at       399,234
write     D17
draw     399,194;431,194
at       431,184
write    D18

------------------------------------------------------------------ part=1, block=k -----------


       block 1k,  cges3a


unit     cges3a
join     cges3b
join     cges3c
join     cges3d
join     cges3f
join     cges3g
join     cges3h
***

unit     cges3b
draw     3044;2444;2423;3023;3044
at       3023
write        CIRCUIT BOARD
at       176,104
write     T1   T2   T3   T4   T5
at       2723
write     T6   T7   T8   T9   T10
at       176,56
write     T11 T12        T14 T15
***

unit     cges3c
draw     165,335;153,309
at       142,289
write    T16
draw     191,327;191,307
at       181,287
write    T18
draw     261,337;245,307
```

```
554  at      235,287
555  write   T17
556  ***

557  unit    cges3d
558  draw    256,215;288,195
559  at      288,185
560  write   T22
561  draw    256,225;288,215
562  at      288,205
563  write   T21
564  draw    256,235;288,235
565  at      288,225
566  write   T20
567  draw    256,245;288,255
568  at      288,245
569  write   T19
570  draw    222,185;238,165
571  at      222,145
572  write   T23
573  draw    51,237;19,257
574  at      3,257
575  write   T24
576  draw    257,185;289,165
577  at      286,148
578  plot    ground
579  ***

580  unit    cges3f
581  draw    327,294;311,274
582  at      295,254
583  write    T28
584  draw    337,294;349,270
585  at      333,250
586  write    T27
587  ***

588  unit    cges3g
589  draw    393,309;409,279
590  at      393,259
591  write    T29
592  draw    452,309;468,289
593  at      468,279
594  write   T30
595  ***

596  unit    cges3h
597  draw    369,181;353,161
598  at      337,141
599  write    T25
600  draw    381,181;389,161
601  at      373,141
602  write    T26
603  draw    393,181;402,168
604  at      398,152
605  plot    ground
```

```
---------------------------------------------------------------- part=1, block=l ----------

      block 11,  cgeend


unit     cgeend
at       710
write    Now jumping to an Index of CGE Experiments.
inhibit  jumpchk
jumpout  cgeindex
stop

---------------------------------------------------------------- part=1, block=m ----------
```

user log

```
stop
cgedata
d0
sellers arizona  08/12/74 2
0

-
30
imsssl stan  08/12/74 1
2

-
19
imsssl stan  08/12/74 1
2

-
19
eichmann e  08/13/74 0
2

-
12
demo wright  08/13/74 2
2

-
08
eichmann e  08/13/74 0
2

-
12
lachman uicc  08/13/74 0
1

-
03
sample cerl  08/13/74 1
4
```

```
653
654  -
655  16
656  davis matha  08/13/74 0
657  3
658
659  -
660  21
661  student cu  08/14/74 0
662  2
663
664  -
665  00
666  student cu  08/14/74 0
667  2
668
669  -
670  00
671  student cu  08/15/74 0
672  2
673
674  -
675  00
676  visitor ee244  08/16/74 0
677  7
678
679  -
680  12
681  student cu  08/16/74 0
682  2
683
684  -
685  00
686  brown d siu  08/16/74 0
687  2
688
689  -
690  18
691  wetstone conn  08/16/74 2
692  3
693
694  -
695  06
696  wetstone conn  08/16/74 2
697  3
698
699  -
700  06
701  sample cerl  08/18/74 0
702  3
703
704  -
705  22
706  sample cerl  08/18/74 0
707  3
708
709  -
```

```
710  22
711  smith arizona  08/19/74 2
712  0
713
714  -
715  28
716  smith arizona  08/19/74 2
717  0
718
719  -
720  28
721  cherub block  08/19/74 0
722  2
723
724  -
725  11
726  becky cerl  08/20/74 0
727  3
728
729  -
730  26
731  becky cerl  08/20/74 0
732  3
733
734  -
735  26
736  paul phys  08/20/74 1
737  6
738
739  -
740  03
741  ashworth siu  08/22/74 0
742  7
743
744  -
745  27
746  ashworth siu  08/23/74 0
747  3
748
749  -
750  13
751  ashworth siu  08/23/74 0
752  3
753
754  -
755  13
756  dan mathk  08/23/74 0
757  3
758
759  -
760  24
761  p mast p  08/23/74 0
762  3
763
764  -
765  22
766  martin pdg  08/26/74 0
```

```
767  1
768
769  -
770  16
771  start
     cgeend    cgeend        607              284
     cgeida    cgeid          23
     cgeidb    cgeid          39               45
     cgem0a    cgem0a         47               21      25      37        69
     cgem0b    cgem0b         68               49      88     283
     cgem0c    cgem0b         87               70     111     160
     cgem0d    cgem0d        110               89     166
     cgem0de   cgem0d        156              161
     cgem0e    cgem0e        165              160     183
     cgem0f    cgem0e        182              167     198
     cgem0g    cgem0g        197              184     254
     cgem0h    cgem0h        253              199
     cgem0i    cgem0h        282              255
     cges1a    cges1a        289              132     135     140       144  151  148
     cges1b    cges1a        300              133
     cges1c    cges1a        337              137
     cges1d    cges1a        353              141
     cges1e    cges1a        369              145
     cges1f    cges1a        402              149
     cges1g    cges1g        417              152
     cges2a    cges2a        444              159
     cges2b    cges2a        451              445
     cges2c    cges2a        480              446
     cges2d    cges2a        500              447
     cges2e    cges2a        511              448
     cges2f    cges2a        516              449
     cges3a    cges3a        527              159
     cges3b    cges3a        535              528
     cges3c    cges3a        546              529
     cges3d    cges3a        557              530
     cges3f    cges3a        580              531
     cges3g    cges3a        588              532
     cges3h    cges3a        596              533
     back          panel     158      160
     data          panel     158
     dosw          panel     116      124     415
     frac          panel      32       34      35      35
     ground        panel     115      122     578     605
     int           panel      31       32      34
     key           panel     158      158     158     158     160       160       161
     lab           panel     158
     nc            panel      27       28      28      29      30   32   31   33   32
                              33       34      34      35      35
     nc1           panel      26       26
     nc2           panel      25       26      27      28      28   30   29   30   29
                              31       31      32      32      32   33   32   33   33
                              33       34      34      35      35        36        36
     next          panel     158      160
     n1            panel     158      159     200     206     212  227  216  234  223
                             237      240     244
     n5            panel     129      134     138     142     146       150  297  292
     n6            panel     130      290     294
```

```
n7         panel      131    135    139    143    147        294        295
n70        panel       20     21     29
solid      panel      117    126
station    panel       31     32     34     35
switch     panel      113    120    308    351    359        400
trmnl      panel      114    118    310    312    314   320  316   322  318
                      324    345    347    349    361   367  363   377  365
                      379    381    383    385    387   396  389   398  394
                      409    411    413    426    428        436        438
v3         panel       34     35
```

```
                              lesson information

        lesson name = cge

        starting date = 07/17/73

        last edited on 08/26/74 at 11.31.45

                   by neal of course eecge

                   at site 7, station 27

        author name = J. P. Neal

        department = E.E.

        telephone number = 333-4351

        discipline = Elec. Engineering

        grade level = Any

        descripion of lesson = A Description of the CGE-PLATO Instructional Laboratory.
```

```
                         lesson cgerl at 2:15 am on tuesday, august 27, 1974
------------------------------------------------------------------ part=1, block=a ------------


       block 1a,  cgerlid

   stop
   ****    For Neal, CGERL, Room 248, EEB.

   One line description of this lesson --

      CGE-PLATO Tests & Special Software Routines

             Divisions of this Lesson:        Block    Unit

           Id for this lesson                cgerlid
           Access from the student mode      rlm0a     rlm0a
           Cge index of lessons              rlm0a     rlm1a
           Listing of connections            rlm0a     rlm2a
           Cc test                           rlm3aρlm3a
           Listing of dial settings          rlm3a     rlm4a
           Dc test                           rlm5a     rlm5a
           Transmit over ext channel         rlm5a     rlm6a
           Repeated check of 1 dial          rlm5a     rlm7a
           Cge checker authoring aids        rlm7b     rlm8a
           Slide display                     rlm9a     rlm9a
           Cge software record-maintenance   rlm10a    rlm10a

           final edit 21 aug 74 neal.

   *list   info
   *list   symbols
   *list   varian,charset,cgeindex,cgechar
   *******
   start
   ext     0                     $$ clears cge hardware
   dataoff
------------------------------------------------------------------ part=1, block=b ------------


       block 1b,  rlm0a

   unit    rlm0a
   course  n51
   jump    ((n51='eecge')$and$user='author'),x,rlm0b
   back    rlmend
   base
   erase
   at      711
   write     Type the number of the following topic in
           which you are interested:
                1. Index to CGE Lessons and Stations
                2. Listing of Current Connections
                3. CC Test
                4. Listing of Current Dial Settings
                5. DC Test
                6. Transmit Data over External Channel
                7. Repeated Check of a Selected Dial
                8. CGE Checker Authoring Aids
                9. Slide Display
               10. CGE Software Record-Maintenance
arrow   2725
match   n150,1,2,3,4,5,6,7,8,9,10
jump    n150,x,rlm1a,rlm2a,rlm3a,rlm4a,rlm5a,rlm6a,rlm7a,rlm8a,rlm9a,rlm10a
***

unit    rlm0b
jumpout plato
***

unit    rlm1a
base
back    rlm0a
next    rlm0a
at      305
write             CGE-PLATO LESSONS

        LESSON              TOPIC

        cge         A Description of the CGE-PLATO Instructional Lab.
        cgerl       CGE-PLATO Tests & Special Software Routines
        ee244       Student List for CGERL Course
        eecge       Author List for CGERL Course
        cgeindex    Router Lesson for Courses ee244 and eecge
        cgedata     Data File for courses ee244 and eecge
        eex00       An Introduction to the CGE Station
        eex01       The Oscilloscope
        eex02       The Audio Oscillator
        eex03       The Function Generator
        eex04       The Constant Voltage/Constant Current Supply
        eex05       The Vacuum Tube Voltmeter
        eex06       Measurements of Transients
        eex07       Measurements of Impedance
        eex08       Measurements of Two-Port Networks
at      2603
write           CGE-PLATO stations in CGERL at 248 EEB:

        Site 7, Station 12, Console *118  w/o experimental equipment
        Site 7, Station 27, Console *324 w/CGE-PLATO I/O & exp. eqpt.
***

unit    rlm2a
base
back    rlm0a
next    rlm2a
join    rlm2b
at      3112
write   Press -NEXT- to check connections again.
```

```
          Press -BACK- when done.

------------------------------------------------------------------------------- part=1, block=c ---------


     block 1c,  rlm2b


unit     rlm2b
define   rlm2b
         cc=o40
         check=n1          $$ marks a checked terminal
         start=n2          $$ first terminal in a node
         termc=n3          $$ marks terminal to be examined
         keytime=v4        $$ records time since last key
         datac=n5          $$ stores data from key
         namterm=n6        $$ name of terminal to be displayed
         screen=n7
         node=n8
at       310
write    LISTING of CURRENT TERMINAL INTERCONNECTIONS
calc     check⇐o0
         start⇐termc⇐1
         keytime⇐clock
         screen⇐320
         node⇐0
time     1
enable
ext      cc+termc          $$ first request for terminal data

entry    rlm2c
pause
goto     (key=timeup)-(key=next$or$key=stop),rls2a,x,rls2b
goto     (key$mask$o1000)=0,rlm2c,x  $$ locks out keyboard
calc     datac⇐key$mask$o37     $$ bottom 5 bits are data bits
         check⇐check$union$(1$cls$(termc-1)) $$marks terminal
         keytime⇐clock
goto     datac=start,rls2c,x
goto     (termc=start)$and$node=6,rls2e,x
writec   n3=n2,<at,-5+n7⇐n7+200>Terminals Connected to NODE <a,o7000+n8⇐n8+1>,,
size     0
calc     namterm⇐termc
calcc    termc=start,screen⇐screen+100,screen⇐screen
at       screen
join     termc=start,rls2d,
calc     namterm⇐datac
at       screen⇐screen+100
join     rls2d
goto     where>3000,rls2e,x
calc     termc⇐datac
ext      cc+termc
goto     rlm2c
***

unit     rls2a
```

```
time      1
goto      (clock-keytime>1.5),x,rlm2c
calc      keytime⇐clock
ext       cc+termc
goto      rlm2c
***

unit      rls2b
pause

entry     rls2e
ext       0
writec    (bitcnt(check)<30)-(screen=320),<at,screen+198>* AND MORE *,
          <at,screen+200>* CHECK COMPLETED *,
          <at,screen+394>* Terminals are not interconnected *
size      0
***

unit      rls2c
goto      start≥30,rls2e,x
calc      start⇐start+1
calc      termc⇐start
goto      (check$ars$(start-1)$mask$1)=0,x,rls2c
ext       cc+termc
goto      rlm2c
***

unit      rls2d
writec    namterm,,,Term 1,Term 2,Term 3,Term 4,Term 5,Term 6,Term 7,
          Term 8,Term 9,Term 10,Term 11,Term 12,GROUND,Term 14,
          Term 15,Scope: A input,Scope: B input,Scope: Trigger,
          Fun-gen: Sqr-wave output,Fun-gen: Trng-wave output,
          Fun-gen: Sine-wave output,Fun-gen: Ramp output,
          Fun-gen: Atten'd output,Fun-gen: Trigger output,
          DC-sup: (+) term.,DC-sup: (-) term,Aud-osc: Right output,
          Aud-osc: left output,VTVM: input,VTVM: output

---------------------------------------------------------------- part=1, block=d -----------


      block 1d,  rlm3a


unit      rlm3a
define    rlm3a
          cc=o40
          termc=n1-9
at        227
write     CC Test
at        318
write     (Press -DATA- to restart)
at        604
write     term   octal   decimal
at        634
write     term   octal   decimal
calc      n1⇐10
calc     v50⇐v52⇐clock
         n51⇐0
time     1
enable
ext      cc+termc

entry    rlm3b
pause
goto     (key=timeup)-(key=next$or$key=stop),rlm3c,x,rlm3d
calc     n(n1)⇐key
         n1⇐n1+1
         v50⇐clock
goto     termc>30,rlm3d,x
ext      cc+termc
goto     rlm3b
***

unit     rlm3c
time     1
goto     clock-v50>1.5,x,rlm3b
calc     v50⇐clock
         n51⇐n51+1
ext      cc+termc
goto     rlm3b
***

unit     rlm3d
ext      0
calc     v53⇐clock
at       3010
write    Number of DATA Transmission Repeats =
showt    n51
at       3110
write    Total DATA Transmission Time =
showt    v53-v52,4.3
write      seconds.
calc     n4⇐0
         n3⇐605
do       rlm3f,n2⇐1,(n1-10)÷2
calc     n3⇐635
do       rlm3f,n2⇐((n1-10)÷2+1),n1-10

entry    rlm3e
pause
jump     (key=next$or$key=back)-(key=data),rlm0a,x,rlm3a
goto     rlm3e
***

unit     rlm3f
calc     n3⇐n3+100
         n145⇐n2
at       n3
showt    n2,2
write
showo    n(n2+9),4
at       n3+9
calc     n99⇐n(n2+9)$mask$o77
```

```
showt   n99
***

unit    rlm4a
base
back    rlm0a
next    rlm4a
join    rlm4b
at      3115
write   Press -NEXT- to check dials again.
        Press -BACK- when done.

-------------------------------------------------------------- part=1, block=e ----------


        block 1e,  rlm4b

unit    rlm4b
define  rlm4b
        dc=o100
        dial=n1
        code=n2
        screen=n3
        keytime=v4
calc    n22⇐nc2⇐nc2+1
do      rlm4c
calc    screen⇐511
        dial⇐1
        keytime⇐clock
time    1
enable
ext     dc+dial

entry   rlm4d
pause
goto    (key=timeup) - (key=next$or$key=stop),rlm4e,x,rlm4f
goto    (key$mask$o1000)=0,rlm4d,x        $$ locksout keyboard
calc    code⇐key$mask$o37
        keytime⇐clock
do      rlm4g                             $$ generates display
calc    dial⇐dial+1
goto    dial>22,rlm4f,x
ext     dc+dial
goto    rlm4d
***

unit    rlm4e
time    1
goto    clock-keytime>1.5,x,rlm4d
calc    keytime⇐clock
ext     dc+dial
goto    rlm4d
***

unit    rlm4f
```

```
ext     0
exit    1
***

unit    rlm4g
at      screen⇐screen+100
writec  dial,,,PLUG-IN,,,,,,,SCOPE,,FUN-GEN,,,,,,
        DC-SUP,,,AUD-OSC,,,VTVM
at      screen+8
writec  dial,,,B VOLTS,TIME,A VOLTS,B PREAMP,
        SWEEP MODE,TRIGGER SOURCE,A PREAMP,
        Y DISPLAY FUNC,X DISPLAY FUNC,
        TRIGGER,MULTIPLIER,CYCLES/SEC,
        OUTPUT,ATTENUATOR,DC LEVEL,METER,
        VOLTAGE,CURRENT,AMPLITUDE,
        RANGE,FREQUENCY,RANGE
at      screen+23
do      dial,x,x,d1,d2,d1,d4,d5,d6,d4,d8,d9,d10,x
do      dial-10,x,x,d11,d12,d13,d14,d15,d16,d17,d18,d19,d20,d21,d22
***

unit    d1
writec  code,-,0,1 m,2 m,5 m,10 m,20 m,50 m,0.1 ,0.2 ,0.5 ,
        1.0 ,2.0 ,5.0 ,10 ,20 ,50 ,100 ,200
write   V full scale
***

unit    d2
writec  code,-,0,10 u,20 u,50 u,100 u,200 u,500 u,
        1 m,2 m,5 m,10 m,
        20 m,50 m,100 m,200 m,500 m,1,2,5,10,20,50,ext
write    sec. full scale
***

unit    d4
writec  code,-,0,-AC,+AC,+DC,-DC,OFF,BAL SET
***

unit    d5
writec  code,-,0,ARM - variable length,
        MAN - variable length,
        AUTO - variable length,
        DRIV - variable length,
        DRIV - variable sweep rate,OFF
***

unit    d6
writec  code,-,0,LINE,AC - ext + 20,DC - ext + 20,AC - ext,
        DC - ext,AC - int,DC - int,,
writec  code-8,,OFF,

---------------------------------------------------------------- part=1, block=f --------
```

block 1f. rlm4c

```
unit    rlm4c
at      419
write   Dial              Current Setting
at      419
write   ----              ------- -------
***

unit    d8
writec  code,-,0,A,B,A & B (CHOP),A & B (ALT),A vs B
***

unit    d9
writec  code,-,0,SWP×5,SWP,EXT
***

unit    d10
writec  code,-,0,INT ,EXT
***

unit    d11
write   times
writec  code,-,0,0.001,0.01,0.1,1.0,10,100,1000,
***

unit    d12
writec  code,-,0,1.1,1.5,1.9,2.3,2.7,3.2,3.6,4.1,4.5,
        5.0,5.4,5.9,6.3,6.8,7.2,7.7,8.0,8.5,9.0,9.4,9.9,10.2
write    Hz (not incl. MULT.)
***

unit    d13
writec  code,-,0,RAMP,SINE,TRIANGLE,SQUARE,
***

unit    d14
writec  code,-,0,2.7,3.5,4.8,6.1,7.2,8.1,8.7,9.8,10.4,11.1,11.5,
        12.0,12.5,13.0,13.3,13.5,14.0,14.1,14.4,14.8,15.0,15.1
write    volts
***

unit    d15
writec  code,-,0,0,0,0,-56.5,-55.5,-52.5,-48,-44,-39,-35,-31,-27,
        -24,-20,-17,-14,-13,-13,-10,2,30,56
write    volts
***

unit    d16
writec  code,-,0,VOLTS,AMPS,
***

unit    d17
writec  code,-,0,0.1,0.9,3.3,5.6,8.2,11.0,13,15,17,20,21,23,26,
        28,30,32,34,36,38,40,42,44
write    volts
***
```

```
unit    d18
writec  code,-,0,0.0,0.0,0.01,0.05,0.07,0.10,0.14,0.17,0.20,0.25,
        0.27,0.29,0.31,0.35,0.37,0.40,0.43,0.46,0.50,0.52,0.55,0.59
write    amperes
***

unit    d19
writec  code,-,0,0.04,1.0,2.0,4.0,6.0,8.0,9.0,10,11,12,14,15,17,
        19,20,21,23,25,26,28,29,30
write    volts rms
***

unit    d20
write   times
writec  code,-,0,1,10,100,200,
***

unit    d21
writec  code,-,0,17,19.2,20.5,21.8,23.4,25.4,28,31.2,35,
        40,46,53,61,71,82,
        94,108,122,140,160,185,210
write    Hz (not incl. RANGE)
***

unit    d22
writec  code,-,0,0.001,0.003,0.01,0.03,0.1,0.3,1.0,3.0,10,30,
        100,300
write    R.M.S. VOLTS full scale

------------------------------------------------------------------ part=1, block=g --------
```

```
     block 1g,  rlm5a

unit    rlm5a
define  rlm5a
        dc=o100
        dial=n1-9
base
at      128
write   DC Test
at      218
write   (Press -DATA- to restart)
calc    n1⇐10
        n101⇐0           $$ counter for number of repeats
time    1                $$ time slice between repeats
calc    v100⇐clock
        v102⇐clock
ext     dc+dial
enable
goto    rlm5b

entry   rlm5c
ext     dc+dial
```

```
entry   rlm5b
pause
goto    key=timeup,rlm5f,x      $$ go to rlmrf for retry
calc    n(n1+1)⇐key
        n1⇐n1+1
        v100⇐clock
goto    key=next$or$dial>22,x,rlm5c
ext     0
calc    v103⇐clock
calc    n4⇐0
at      410
write    Dial   Alpha    Octal            Binary
do      rlm5d,n2⇐1,27
at      3010
write   Number of Repeats=
showt   n101
at      3110
write   Total Transmission Time=
showt   v103-v102,4.3
write     seconds.
back    rlm0a
next    rlm0a
data    rlm5a
***

unit    rlm5d
calc    n3⇐400+100*n2
at      n3+12
write   ‹t,n2,2›        ‹a,n(n2+10)$mask$o77›         ‹at,n3+28›‹o,n(n2+10),4›
at      where+7
do      rlm5e,n120⇐1,2
at      where
do      rlm5e,n120⇐3,10
exit    -(n2≥n1-10)
***

unit    rlm5e
showt   (n(n2+10)$ars$(10-n120))$mask$o1,1
***

unit    rlm5f                          $$ handles retries
time    1
goto    clock-v100>2,x,rlm5b
calc    v100⇐clock
        n101⇐n101+1
ext     dc+dial
goto    rlm5b
***

unit    rlm6a
back    rlm0a
erase
at      510
write   Enter the code which you wish to transmit
        over the external channel.
next    rlm6a
arrow   910
```

```
store     n1
ok
at        1210
write     Press -NEXT- to transmit same code again.
          Press -BACK- to transmit a different code.
inhibit erase
jump      rlm6c
***

unit      rlm6b
at        1210
write     EXT OUTPUT
back      rlm6a
next      rlm6b
ext       n1
at        1510
showo     n1,5
***

unit      rlm6c
inhibit erase
ext       n1
back      rlm6a
next      rlm6c
***

unit      rlm7a
back      rlm0a
ext       0
at        510
write     Type the CGE number of the dial you wish to
          have checked repeatedly.
arrow     814
store     n20
ok
jump      rlm7b

------------------------------------------------------------------ part=1, block=h ---------


     block 1h,  rlm7b


unit      rlm7b
at        210
write              REPEATED CHECK of a SINGLE DIAL

              Press -STOP- to stop test.

              Then, press -NEXT- to chose another dial,
              or -BACK- to return to index.
at        914
write     Dial Number = <z,n20>
at        933
write     Code =
at        1139
```

```
write    Code      Time
at       1314
write    Total checks =
         Changes =
         Repeats =
at       1814
write    Total time =
         Time/Check =
mode     rewrite
enable
ext      o100+n20
pause
calc     n3⇐key$mask$o77
calc     n2⇐n6⇐0
         n1⇐1
         n11⇐0
         n12⇐0
         n13⇐1240
         v7⇐clock
         v5⇐clock
time     1
ext      o100+n20

entry    rlm7be
pause
calc     v10⇐clock
calc     n13⇐n13+100
goto     n13>3200,rlm7bf,x
at       n13
write    «a,n3»          «z,v10-v7»

entry    rlm7bf
goto     (key=stop$or$key=next),rlm7c,x
goto     key=timeup,rlm7d,x
goto     (key$mask$o1000)=0,rlm7be,x    $$ locks out keyboard
calcc    n3=key$mask$o77,n12⇐n12,n12⇐n12+1
calc     n3⇐key$mask$o77
at       940
showa    key$mask$o77
at       944
write    o«o,key,4»
calc     n1⇐n1+1
calc     v8⇐clock
at       1329
write    «z,n1»
          «z,n6»
          «z,n12»
at       1829
write    «z,v8-v7»
         «z,(v8-v7)÷n1»
calc     v5⇐clock
ext      o100+n20
goto     rlm7be
***

unit     rlm7c
calc     v8⇐clock
```

```
ext      0                              $$ clears hardware
pause                                   $$ waits for last timeup key
mode     rewrite
at       1329
write    <z,n1>
          <z,n6>
          <z,n12>
at       1829
write    <z,v8-v7>
         <z,(v8-v7)+n1>
at       2214
write    CHECK COMPLETED

entry    rlm7ce
pause                              $$ loop absorbs spurious keys
goto     key=next$or$key=back,x,rlm7ce
jump     key=next,rlm7a,rlm0a
***

unit     rlm7d
time     1
goto     clock-v5>1,x,rlm7be
calc     n6⇐n6+1
         v5⇐clock
ext      o100+n20
goto     rlm7be

unit     rlm8a
erase
back     rlm0a
at       510
write           CGE Checker Authoring Aids

            This demonstration is intended to give authors
         an opportunity to explore the use of the ckc and
         ckd series subroutines.

         Press  c  for connection check subroutine demo.

         Press  d  for dial check subroutine demo.
at       2210
write    NOTE: Authors in the student mode can press -MICRO-
         to pass OK through a check. Students cannot do this.
arrow    1910
long     1
answer   c
jump     rlm8b
answer   d
jump     rlm8e

------------------------------------------------------------ part=1, block=i ---------


        block 1i,  rlm8b
```

```
unit    rlm8b
erase
inhibit erase
back    rlm8a
next    rlm8b
at      510
write      Connection Check Subroutine Demonstration

        Current Author Codes
at      910
write   Author Code  n33= <a,n33,30>


        Best Match       = <a,n36,30>

        Hardware Code    =
at      1428
do      rlm8c,n75⇐1,30
at      1610
write   Press DATA to change Author Code
data    rlm8d
at      1910
write   Type the number of the ckc subroutine you wish to try.


        1) ckc          (performs a connection check)
        2) ckcw         (performs a CC and writes errors)
        3) ckc1         (counts errors of new pack vs ckc)
        4) ckc1w        (same as ckc1 and writes errors)
        5) ckc2         (counts errors of best match vs ckc)
        6) ckc2w        (same as ckc2 and writes results)
arrow   2810
long    1
specs   nookno
match   n51,1,2,3,4,5,6
join    n51,x,ckc,ckcw,ckc1,ckc1w,ckc2,ckc2w
at      3110
write    <z,-n47> Errors Found in Setup
back    rlm8b
***

unit    rlm8c
calc    n76⇐0
move    n30,n75,n76,10
calcc   ((n76=0)-(n76="0")),n76⇐"0",n76⇐n76,n76⇐"4"
showa   n76
***

unit    rlm8d
at      1010
write   Desired Code
arrow   1026
copy    n33,30
long    30
storea  n33,30
ok
jump    rlm8b
```

```
***

unit    rlm8e
erase
inhibit erase
base
back    rlm8a
next    rlm8e
at      510
write         Dial Check Subroutine Demonstration

        Current Author Codes
at      910
write   Author Code  n33=
at      928
write   <a,n33,50>


at      1310
write   Best Match       = <a,n39,50>

        Hardware Code    = <a,n30,22>
at      1710
write   Press DATA to change Author Code.
data    rlm8f
at      1910
write   Type the number of the ckd subroutine you wish to try.


        1) ckd          (performs a dial check)
        2) ckdw         (performs a DC and writes errors)
        3) ckd1         (counts errors of new pack vs ckd)
        4) ckd1w        (same as ckd1 and writes errors)
        5) ckd2         (counts errors of best match vs ckd)
        6) ckd2w        (same as ckd2 and writes results)
arrow   2810
long    1
match   n51,1,2,3,4,5,6
join    n51,x,ckd,ckdw,ckd1,ckd1w,ckd2,ckd2w
at      3110
write    <z,-n47> Errors Found in Setup
back    rlm8e
***

unit    rlm8f
at      1110
write   Desired Code
arrow   1126
copy    n33,50
long    50
storea  n33,50
ok
end
---------------------------------------------------------------- part=1, block=j --------
```

```
     block 1j,  rlm9a

unit    rlm9a
back    rlm0a
next    rlm9b
calcc    (station=251),n101⇐256,512
slide   noslide
at      107
write   SLIDE NO.     CGE SLIDE

          0          Test Slide
          1          CGERL Entrance
          2          The EE244 Laboratory
          3          CGE-PLATO System Description
          4          Orientation of the CGE Station
          5          Scope & Function Generator
          6          Aud. Osc., VTVM, & DC Supply
          7          Layout of Sensed Dials & Terminals
          8          List of Sensed Dials & Terminals
          9 - 18     Dial Setting Codes
         19          Resistor Color Code
         20 - 21     E E Symbols & Units
         22          Recommended Unit Prefixes
         23          Defined Physical Values
         24 - 26     Physical Constants
         27 - 32     SCOPE -     Use of Dials and Terminals
         33 - 35     SCOPE -     Manufacturer's Specifications
         36 - 44     PLUG-IN -   Use of Dials and Terminals
         45 - 50     PLUG-IN -   Manufacturer's Specifications
         51 - 53     FUN.GEN. -  Use of Dials and Terminals
         54 - 56     FUN.GEN. -  Manufacturer's Specifications
         57 - 60     AUD.OSC. -  Use of Dials and Terminals
         61 - 62     AUD.OSC. -  Manufacturer's Specifications

        Press -NEXT- to see remainder of Slide List.

------------------------------------------------------------- part=1, block=k -----------

     block 1k,  rlm9b

unit    rlm9b
back    rlm9a
next    rlm9c
calcc    (station=251),n101⇐256,512
slide   noslide
at      107
write   SLIDE NO.     CGE SLIDE

         63 - 66     VTVM -      Use of Dials and Terminals
         67 - 68     VTVM -      Manufacturer's Specifications
         69 - 71     DC SUPP -   Use of Dials and Terminals
         72 - 75     DC SUPP -   Manufacturer's Specifications
```

```
                76          Graph of a Transient
                81          CGE Station Picture


                88          Gunther Frank at CGE
                89          Doug Dowden & Frank at CGE
                90          Dave Borth at CGE
                91          Doug Zanter & Borth at CGE
                92          Borth & Dan Derrig at CGE
                93-97       CGE-PLATO Interface

                Type slide no.       ,press -NEXT-, or -BACK- to return.
      arrow     3121
      store     n100
      ok
      erase
      goto      (n100≤255),rlm9c,rls9a
      ***

      unit      rls9a
      back      rlm9a
      next      rlm9a
      at        1210
      write     NO!  Type  a number less than 256..
      ***

      unit      rlm9c
      back      rlm9a
      next      rlm9d
      at        3204
      write        This is slide ‹z,n100›.  Press -NEXT- for next slide
      slide     n100
      ***

      unit      rlm9d
      back      rlm9a
      next      rlm9a
      calc      n100⇐n100+1
      goto      (n100≤255),rlm9c,x
      slide     512
      at        1210
      write     You can't show a slide greater than 255.
      ***

      unit      rlm9e
      slide     n100+512
      back      rlm0a
      next      rlm0a
      goto      rlm0a
----------------------------------------------------------------- part=1, block=1 ---------


          block 11,  rlm10a
```

```
unit    rlm10a
back    rlm0a
next    rlm0a
*calc    nc(1)⇐10033       $$ format for changing cc counter
*calc    nc(2)⇐11069       $$ format for changing dc counter
at      505
write               CGE Software Record-Maintenance


        CAUTION: In order to avoid interference with automatic
        record keeping and avoid loss of log records, the
        following tasks will only be performed by a CGE author
        specifically authorized by the Director of CGERL.

             If specifically authorized, select the operation
        you wish to perform:

        A. Record chronologically a remark in the cgedata record.

        B. Print and clear the uselog maintained in the common
        in lesson cge.

        C. Print and clear the statlog maintained in lesson
        cgeindex.
arrow   2810
long    1
specs   bumpshift
match   n150,a,b,c
jump    n150,x,rlm10b,rlm10c,rlm10d
***

unit    rlm10b
calc    n21⇐nc(4)
        nc(4)⇐nc(4)+3
        nc(n21)⇐'inst
at      907
write      At the beginning of each day of operation, type
        the present date or, to record a note about a student
        difficulty, type the student's name.
arrow   1311
long    8
storea  nc(n21+1)
ok
at      1509
write      Type the desired code or remark:

        ok      - CC and DC checked and new day started.

        pdn     - Plato down.

        cdn     - CGE hardware down.

        unxabs - unexcused absence.

        xabs    - excused absence.
```

```
                or any other 8 character remark.
      arrow     2911
      long      8
      storea    nc(n21+2)
      ok
      jumpout   plato
      ***

      unit      rlm10c
      next      rlm0a
      back      rlm0a
      at        806
      write        The uselog in cge should be printed when 300
                lines have been entered therein. Do this as follows:

                1. Copy the common, uselog, from cge into cgerl as
                block 1b, rename it userlog, convert it to a source,
                and mark it so it will not be readin.

                2. Insert "*list  label, user log (date)" as the
                first line in userlog and "*list  off" as the last
                line in userlog in cgerl.

                3. Request a print of cgerl.

                4. Enter cge, convert the common uselog to a source,
                delete all entries, then reconvert uselog to a common,
                so it can continue to record users of lesson cge.

                5. After the print of the userlog in cgerl has been
                received, delete the block userlog from cgerl.

  -------------------------------------------------------------------- part=1, block=m ---------


            block 1m,  rlmend:


      unit      rlm10d
      help1     rlm10e
      lab1      rlm10i
      next      rlm0a
      back      rlm0a
      at        506
      write        The statlog in cgeindex should be printed when 300
                lines have been entered therein. Do this as follows:

                1. Warning- this step must be done only once !!
                Convert the common, statlog, to printable form from
                here by pressing -HELP1-, once.

                2. Copy the common statlog into cgerl, convert it to
                a source, rename the block studstat, move it to
                block 1b, and mark it not to be readin.

                3. Zero the original copy of the common by pressing
```

```
         -LAB1- while in here in the student mode.

         5. Enter *list  label,student statistics (date) as
         the first line in studstat, and "*list  off" as
         the last line in studstat.

         6. Request a print of lesson cgerl.

         7. After the print of studstat in cgerl has been
         received, delete the block studstat from cgerl.
***
unit     rlm10e
calc     n1⇐11                        $$ changes 6 to 11

entry    rlm10e1
calc     n150⇐nc(n1-1)
calcc    n150='inst',n1⇐n1+3,n1⇐n1
jump     n150='inst',rlm10e1,x
itoa     nc(n1+1),nc(n1+1)
itoa     nc(n1+2),nc(n1+2)
itoa     nc(n1+3),nc(n1+3)
itoa     nc(n1+4),nc(n1+4)
itoa     nc(n1+6),nc(n1+6)
jump     rlm10g
***
unit     rlm10f
calc     n1⇐n1+8                       $$ next student
jump     n1≤322,rlm10e1,x
at       410
write    Common is now printable.
pause
jumpout  plato
***
unit     rlm10g
calc     v50⇐vc(n1)       $$ chgd from n1+5 so counters prt.
calc     n51⇐int(v50)
calc     n52⇐10000×frac(v50)
jump     n51≤9,rlm10g1,x
jump     n51≤99,rlm10g2,x
jump     n51≤999,rlm10g3,x

entry    rlm10g1
calc     n53⇐1
goto     rlm10h

entry    rlm10g2
calc     n53⇐2
goto     rlm10h

entry    rlm10g3
calc     n53⇐3
goto     rlm10h
***
```

```
925  unit     rlm10h
926  calc     n54⇐'.'
927  itoa     n51,n51
928  itoa     n52,n52
929  move     n54,1,n51,n53+1,1
930  move     n52,1,n51,n53+2,4
931  calc     nc(n1+5)⇐n51
932  jump     rlm10f
933  ***

934  unit     rlm10i
935  calc     nc(4)⇐10
936  zero     nc5,318
937  calc     nc322⇐0
938  jump     rlm0a
939  ***

940  unit     rlmend
941  press    next
942  end      lesson
943  ***
944  use      eex00,ck1
945  use      ck2
946  use      ck3
947  use      ck4
948  use      ck5
     ckc            not found                    640
     ckcw           not found                    640
     ckc1           not found                    640
     ckc1w          not found                    640
     ckc2           not found                    640
     ckc2w          not found                    640
     ckd            not found                    694
     ckdw           not found                    694
     ckd1           not found                    694
     ckd1w          not found                    694
     ckd2           not found                    694
     ckd2w          not found                    694
     d1         rlm4b              299           296         296
     d10        rlm4c              337           296
     d11        rlm4c              340           297
     d12        rlm4c              344           297
     d13        rlm4c              349           297
     d14        rlm4c              352           297
     d15        rlm4c              357           297
     d16        rlm4c              362           297
     d17        rlm4c              365           297
     d18        rlm4c              370           297
     d19        rlm4c              375           297
     d2         rlm4b              304           296
     d20        rlm4c              380           297
     d21        rlm4c              384           297
     d22        rlm4c              390           297
     d4         rlm4b              310           296         296
     d5         rlm4b              313           296
     d6         rlm4b              320           296
     d8         rlm4c              331           296
```

```
d9          rlm4c         334        296
rlmend      rlmend        940         31
rlm0a       rlm0a          28         56        57        84   434   222   435   238
                                     460       491       582   791   593   742   710
                                     793       796       797   867   846   868   847
                                     938
rlm0b       rlm0a          51         30
rlm1a       rlm0a          54         49
rlm10a      rlm10a        795         49
rlm10b      rlm10a        819        817
rlm10c      rlm10a        845        817
rlm10d      rlmend        864        817
rlm10e      rlmend        887        865
rlm10e1     rlmend        889        892       902
rlm10f      rlmend        900        932
rlm10g      rlmend        908        898
rlm10g1     rlmend        915        912
rlm10g2     rlmend        918        913
rlm10g3     rlmend        921        914
rlm10h      rlmend        925        917       920       923
rlm10i      rlmend        934        866
rlm2a       rlm0a          82         49        85
rlm2b       rlm2b          91         86
rlm2c       rlm2b         112        115       133       137         140         157
rlm3a       rlm3a         169         49       222
rlm3b       rlm3a         187        195       199       203
rlm3c       rlm3a         197        189
rlm3d       rlm3a         205        189       193
rlm3e       rlm3a         220        223
rlm3f       rlm3a         225        217       219
rlm4a       rlm3a         236         49       239
rlm4b       rlm4b         245        240
rlm4c       rlm4c         325        253
rlm4d       rlm4b         260        263       270       274         277
rlm4e       rlm4b         272        262
rlm4f       rlm4b         279        262       268
rlm4g       rlm4b         283        266
rlm5a       rlm5a         395         49       436
rlm5b       rlm5a         414        411       453       457
rlm5c       rlm5a         412        420
rlm5d       rlm5a         438        426
rlm5e       rlm5a         448        443       445
rlm5f       rlm5a         451        416
rlm6a       rlm5a         459         49       465       478         487
rlm6b       rlm5a         475        479
rlm6c       rlm5a         484        473       488
rlm7a       rlm5a         490         49       582
rlm7b       rlm7b         501        499
rlm7be      rlm7b         535        545       563       586         590
rlm7bf      rlm7b         542        539
rlm7c       rlm7b         565        543
rlm7ce      rlm7b         579        581
rlm7d       rlm7b         584        544
rlm8a       rlm7b         591         49       614       665
rlm8b       rlm8b         611        607       615       643         659
rlm8c       rlm8b         645        624
rlm8d       rlm8b         651        627
```

```
rlm8e    rlm8b        661           609     666     697
rlm8f    rlm8b        699           682
rlm9a    rlm9a        709            49     742     768  781  769  782  774
rlm9b    rlm9b        741           711
rlm9c    rlm9b        773           743     765     784
rlm9d    rlm9b        780           775
rlm9e    rlm9b        789
rls2a    rlm2b        135           114
rls2b    rlm2b        142           114
rls2c    rlm2b        151           119     155
rls2d    rlm2b        159           126     129
rls2e    rlm2b        144           120     130     152
rls9a    rlm9b        767           765
back       rlm3a      222
back       rlm5a      581
bitcnt     rlm2b      146
cc         rlm2b       93     111   132     139     156
cc         rlm3a      171     186   194     202
check      rlm2b       94     104   117     117     146       155
clock      rlm2b      106     118   137     138
clock      rlm3a      182     192   199     200     207
clock      rlm4b      256     265   274     275
clock      rlm5a      407     408   419     422     453  532  454  537  531
                      553     561   566     586     588
code       rlm4b      249     264   300     305     311  323  314  332  321
                      335     338   342     345     350  363  353  366  358
                      371     376   382     385     391
data       rlm3a      222
datac      rlm2b       98     116   119     127     131
dc         rlm4b      247     259   269     276
dc         rlm5a      397     409   413     456
dial       rlm4b      248     255   259     267     267  276  268  285  269
                      288     296   297
dial       rlm5a      398     409   413     420     456
frac       rlm5a      911
int        rlm5a      910
key        rlm2b      114     114   114     115     116
key        rlm3a      189     189   189     190     222       222       222
key        rlm4b      262     262   262     263     264
key        rlm5a      416     417   420     525     543  545  543  546  544
                      547     549   551     581     581       582
keytime    rlm2b       97     106   118     137     138
keytime    rlm4b      251     256   265     274     275
n          rlm3a      190     231   233
n          rlm5a      417     441   441     449
namterm    rlm2b       99     123   127     160
nc         rlm5a      820     821   821     822     829  931  841  935  890
nc2        rlm4b      252     252
nc322      rlm5a      937
nc5        rlm5a      936
next       rlm2b      114
next       rlm3a      189     222
next       rlm4b      262
next       rlm5a      420     543   581     582     941
node       rlm2b      101     108   120
noslide    rlm5a      713     745
n1         rlm2b       94
```

n1	rlm3a	172	181	190	191	191		217	219	219
n1	rlm4b	248								
n1	rlm5a	398	404	417	410	418	480	446	482	467
		486	527	552	552	555	576	560	888	571
		890	891	891	891	891	902	901	909	901
		931								
n100	rlm5a	762	765	777	778	783		783	790	784
n101	rlm5a	405	429	455	455	712		744		
n11	rlm5a	528								
n12	rlm5a	529	546	546	546	546		557		573
n120	rlm5a	443	445	449						
n13	rlm5a	530	538	538	539	540				
n145	rlm3a	227								
n150	rlm2b	48	49							
n150	rlm5a	816	817	890	891	892				
n2	rlm2b	95	121							
n2	rlm3a	217	219	227	229	231		233		
n2	rlm4b	249								
n2	rlm5a	426	439	441	441	441		446	526	449
n20	rlm5a	497	509	523	534	562		589		
n21	rlm5a	820	822	829	841					
n22	rlm4b	252								
n3	rlm2b	96	121							
n3	rlm3a	216	218	226	226	228		232		
n3	rlm4b	250								
n3	rlm5a	439	440	441	525	541		546		547
n30	rlm5a	647	679							
n33	rlm5a	620	655	657	673	703		705		
n36	rlm5a	621								
n39	rlm5a	677								
n4	rlm3a	215								
n4	rlm5a	423								
n47	rlm5a	642	696							
n5	rlm2b	98								
n51	rlm2b	29	30							
n51	rlm3a	183	201	201	210					
n51	rlm5a	639	640	693	694	910	914	912	929	913
		930	931							
n52	rlm5a	911	930							
n53	rlm5a	916	919	922	929	930				
n54	rlm5a	926	929							
n6	rlm2b	99								
n6	rlm5a	526	556	572	587	587				
n7	rlm2b	100	121	121						
n75	rlm5a	624	647							
n76	rlm5a	646	647	648	648	648	648	648	649	648
n8	rlm2b	101	121	121						
n99	rlm3a	233	234							
screen	rlm2b	100	107	124	124	124	128	124	128	125
		146	146	147	148					
screen	rlm4b	250	254	284	284	287		295		
start	rlm2b	95	105	119	120	124	153	126	153	152
		154	155							
station	rlm5a	712	744							
stop	rlm2b	114								
stop	rlm3a	189								
stop	rlm4b	262								

```
stop        rlm5a        543
termc       rlm2b         96     105     111     117     120  126  123  131  124
                         132     139     154     156
termc       rlm3a        172     186     193     194     202
timeup      rlm2b        114
timeup      rlm3a        189
timeup      rlm4b        262
timeup      rlm5a        416     544
user        rlm2b         30
vc          rlm5a        909
v10         rlm5a        537     541
v100        rlm5a        407     419     453     454
v102        rlm5a        408     432
v103        rlm5a        422     432
v4          rlm2b         97
v4          rlm4b        251
v5          rlm5a        532     561     586     588
v50         rlm3a        182     192     199     200
v50         rlm5a        909     910     911
v52         rlm3a        182     213
v53         rlm3a        207     213
v7          rlm5a        531     541     559     560     575     576
v8          rlm5a        553     559     560     566     575     576
where       rlm2b        130
where       rlm5a        442     444

                                  lesson information


          lesson name = cgerl

          starting date = 11/20/73

          last edited on 08/21/74 at 10.52.53

                    by neal of course eecge

                    at site 7, station 27

          author name = J. P. Neal

          department = Elec. Engg.

          telephone number = 333-4351

          discipline = E E

          grade level = CGE authors

          descripion of lesson = CGE-PLATO Tests & Special Software Routines.
```

```
                            lesson cgeindex at 2:34 am on thursday, september 5, 1974
------------------------------------------------------------------ part=1, block=a ---------


        block 1a,  cgeindexid

stop
****     For Neal, CGERL, Room 248, EEB.

One line description of this lesson --

    The Router Lesson for Courses ee244 and eecge.

            Divisions of this Lesson:         Block     Unit

          Router unit                          cgestart cgestart
          Index of cge experiments             cgeind   cgeind
          End-exp questionaire                 quest1   quest1
          Table of plato characters            charplato
          Table of cge characters              charcge
          Chars for cge character set          cgechar
          Common for student statistics        statlog

          final edit 29 aug 74 neal.

*list   info
*list   symbols
*list   charset,(* )
*list   varian,charset,cgeindex,cgechar
*******
start
write   ‹at,1010› Loading the CGE Character Set
stop
doto    8loop,n3⇐0,127          $$ this sequence will insert
char    n3                      $$ blanks in all r/w charset
        0,0,0,0,0,0,0,0         $$ spaces before loading the
8loop                           $$ cge character set
start
charset cgeindex,cgechar
erase
dataon
ext     0
------------------------------------------------------------------ part=1, block=b ---------


        block 1b,  cgestart


unit    cgestart
common  cgeindex,statlog,322
name    n2
jump    n2='inst',instruct,x
jump    user='student'$and$station≠251,x,cgeind
jump    user='student'$and$station≠236,x,cgeind
at      1214
write   At this time you may only have access to CGE-PLATO
        at the CGE Research Laboratory, Room 248 EEB.
pause   3
jumpout plato
***

unit    instruct
at      1210
write   One moment please
jumpout cgerl,inst
***

unit    cgeind3
next    cgeind3
at      510
write   You are not at the CGE station in Room 248 EEB.

        Therefore, I will send you back to our title page.
pause   3
jumpout cge
at      1010
write     Please be patient.
***

unit    cgeind4
jump    n2≠'ee244',cont1,x
join    n3=nc(nc(4)-8)$and$rstart1=nc(nc(4)-7),old,new
*         $$ 8,7 instead of 6,5
calc    nc(n21)⇐n3
        nc(n21+1)⇐rstart1

entry   cont1
jumpout resume
***

unit    cgeind2
at      1210
write   You are not at the CGE Station.  You will be
        taken to Sample when you press next.  Press
        Shift-Stop if you want to leave.
pause
inhibit jumpchk
at      3224
write   One Moment Please!
jumpout sample
***

unit    skiper
at      510
write   now going to lesson CGE
inhibit jumpchk
jumpout cge
------------------------------------------------------------- part=1, block=c -----------
```

block 1c, cgeind

```
unit    cgeind
route   end lesson,cgeind
route   error,cgeind  $$ specify where to go on exec. error
term    index
at      207
write     COMPUTER-GUIDED EXPERIMENTS       REFERENCES

           0.  An Intro. to the CGE Station    Chap. 1,2,3
           1.  The Oscilloscope                Chap. 9
           2.  The Audio Oscillator            Chap. 13
           3.  The Function Generator          Chap. 14
           4.  The DC Supply                   Chap. 8
           5.  The Vacuum Tube Voltmeter       Chap. 4,12
           6.  Measurements of Transients      Chap. 14
           7.  Measurements of Impedance       Chap. 3
           8.  Two-Port Networks

             The above experiments should be completed in
          sequence.  Prior to attempting an experiment, you
          should have read the above references in:

             Guide to Electronic Measurements and Laboratory
          Practice, by S. Wolf, Prentice-Hall, 1973.

             While in any experiment:

          To return to this page, -TERM- index.
          To record  your comments, -TERM- comment.
          To read tech. data and spec., -TERM- slides.

             Select an experiment by typing its number, or
          reenter where you shift-stopped out by pressing r.
arrow   3010
long    1
match   n1,0,1,2,3,4,5,6,7,8,r
course  n2
jump    station=236$and$n2='ee244',cgeind2,x
jump    station=251$or$n2='eecge',x,cgeind3
jump    n1,x,cgeind1
judge   no
at      3110
write   Type the number  0,1,2 ... etc.
***

unit    cgeind1
course  n2
name    n3
calc    n3⇐n3$mask$o77777777777777770000
jump    n1,x,x,x,x,x,x,x,x,x,x,cgeind4
jump    n2≠'ee244',cont,x
calcs   n1,nc(3)⇐'x','eex00','eex01','eex02','eex03','eex04','eex05','eex06','eex07','eex08'
join    n3=nc(nc(4)-8)$and$nc(3)=nc(nc(4)-7),old,new
```

```
calc     nc(n21)⇐n3
         nc(n21+1)⇐nc(3)

entry    cont
at       510
write    Now going to experiment selected.
inhibit  jumpchk
jumpout  n1;x;eex00;eex01;eex02;eex03;eex04;eex05;eex06;eex07;eex08
***

unit     old
calc     n21⇐nc(4)-8   $$ 8 instead of 6
exit     1
***

unit     new
calc     n21⇐nc(4)
         nc(4)⇐nc(4)+8   $$ 8 instead of 6
exit     1

-------------------------------------------------------------- part=1, block=d -----------


      block 1d,   quest1

*****    End of Experiment Questionaire    *****

unit     quest1
at       810
write       You have completed this experiment.

            Please complete the following questionaire,
         in order to bring your comments to date.

               Please type the number of the multiple-
         choice statement below which best reflects
         your present opinion.

         A.   I believe my last CGE experiment is worthwhile.

              1.    Strongly Agree
              2.    Agree
              3.    Undecided
              4.    Disagree
              5.    Strongly Disagree
arrow    2510
long     1
ok
***

unit     quest2
at       1210
write    B.    I would have learned more about the
         topic of this experiment in a conventional
         laboratory course.
```

```
                    1.   Strongly Disagree
                    2.   Disagree
                    3.   Undecided
                    4.   Agree
                    5.   Strongly Agree
     arrow    2510
     long     1
     ok
     ***

     unit     quest3
     at       810
     write    C.    How would you advise a friend who
              was considering taking a Computer-Guided
              Experimental section of the Introductory
              EE Laboratory course, EE244.

                   1.   Fight tooth and nail to get into CGE.
                   2.   Take the CGE section if reasonably possible.
                   3.   Take the CGE section only if convenient.
                   4.   Avoid the CGE section if convenient.
                   5.   Avoid CGE like a plague.
     arrow    2510
     long     1
     ok
     ***

     unit     quest4
     at       1210
     write    D.     Have you previously covered the topic of your
              last CGE experiment in any other laboratory course ?
     arrow    1640
     long     1
     ok

------------------------------------------------------------------ part=1, block=e ---------


         block 1e,  comment1


     unit     comment1
     back     cgeind
     at       510
     write         You are invited to type any final comments you
              care to offer!


              Press -NEXT- to enter another line of comment.

              Press -BACK- when finished.
     calc     n1⇐1110

     entry    comment2
     arrow    n1⇐n1+100
     jkey     back
```

```
ok
endarrow
goto      key=next,comment2,x
press     back
------------------------------------------------------------- part=1, block=f -----------


     block 1f,  charplato

***  The following PLATO character sets are in use:

*id       Normal lower case (lc):

*lc1      a b c d e f g h i j k l m n o p q r s t u v w x y z
*lc2      0 1 2 3 4 5 6 7 8 9 = + ≑ - ÷ × ; , . /

*id       Normal upper case (uc):

*lc1      a b c d e f g h i j k l m n o p q r s t u v w x y z
*uc1      A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

*lc2      0 1 2 3 4 5 6 7 8 9 = + ≑ - ÷ × ; , . /
*uc2      < > [ ] $ % _ ' * ( ) Σ   Δ ∩ ∪ : " ! ?

*id       MICRO then key above the character:

*lc1      a b c d e f g h i j k l m n o p q r s t u v w x y z
*char     α β   δ               λ μ   ° π   ρ σ θ     ω

*lc2      0 1 2 3 4 5 6 7 8 9 = + ≑ - ÷ × ; , . /
*char     ( )       @ ▷ 7     ≠ &         ~ ‡   \

*lc1      a b c d e f g h i j k l m n o p q r s t u v w x y z
*uc1      A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
*char     ←    ,→         |                           ↑ ↓

*lc2      0 1 2 3 4 5 6 7 8 9 = + ≑ - ÷ × ; , . /
*uc2      < > [ ] $ % _ ' * ( ) Σ   Δ ∩ ∪ : " ! ?
*char     ≤ ≥ { } #           ≡     Δ

*id       ACCESS then key above the char (ACCESS ≡ shift □):

*lc1      a b c d e f g h i j k l m n o p q r s t u v w x y z
*char     α β   δ               λ μ   ° π   ρ σ θ     ω
*lc2      0 1 2 3 4 5 6 7 8 9 = + ≑ - ÷ × ; , . /
*char     ( ) 2 3 4 @ ▷ 7 8 9 ≠ &   - ÷ × ~ ‡ . \

*lc1      a b c d e f g h i j k l m n o p q r s t u v w x y z
*uc1      A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
*char     ← B C → E F G H I J K L M N O P Q R S T U V ↑ ↓ Y Z

*lc2      0 1 2 3 4 5 6 7 8 9 = + ≑ - ÷ × ; , . /
*uc2      < > [ ] $ % _ ' * ( ) Σ   Δ ∩ ∪ : " ! ?
*char     ≤ ≥ { } # % _ ' * { ≡ Σ   Δ ∩   : " ! ?
```

```
252  ***         End of PLATO Character listings.
-------------------------------------------------------------------------------- part=1  block=g ----------

          block 1g,   charcge

254  ***  The following characters are in the CGE Character Set:

255  *id       FONT then key above the char (FONT = shift MICRO):

256  **  Position numbers of cge characters (read down):

257  *          1 2 3 4 5 6 7 8 9 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2
258  *                            0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6

259  *lc1       a b c d e f g h i j k l m n o p q r s t u v w x y z
260  *char      ∕ ÷ ⫯ ⊢ → ⌐ ^ - β     ⎫   ◆ ⋍ ⊤ ← { √ ≟ ⌐ | ↑ ↓   Ω

261  **  Position numbers of cge characters (read down):

262  *          2 2 2 3 3 3 3 3 3 3 4 3 5 3 4 5 5 6 6 4
263  *          7 8 9 0 1 2 3 4 5 6 4 7 3 8 8 2 9 1 2 0

264  *lc2       0 1 2 3 4 5 6 7 8 9 = + ≑ - ÷ × ; , . /
265  *char                          ≈ +   −         -

266  **  Position numbers of cge characters (read down):

267  *          6 6 6 6 6 7 7 7 7 7 7 7 7 7 7 8 8 8 8 8 8 8 8 8 8 9
268  *          5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0

269  *lc1       a b c d e f g h i j k l m n o p q r s t u v w x y z
270  *uc1       A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
271  *char      |   ⊣   ϵ ∨ ⌐   ⌡     ō ┌ └ ┐ ┘   ⋟ ¯ / ↗         ◆

272  **  Position numbers of cge characters (read down):

273  *                            1 1 1   1 1 1 1   1 1
274  *          9 9 9 9 9 9 9 9 9 0 0 0   0 1 1 2 6 2 0
275  *          1 2 3 4 5 6 7 8 9 0 8 1   2 2 6 3 0 4 4


276  *lc2       0 1 2 3 4 5 6 7 8 9 = + , - ÷ × ; , . /
277  *uc2       < > [ ] $ % _ ' * ( ) Σ   Δ ^ ∪ : " ! ?
278  *char                            ∫   _         |

279  *id       FONT then shift □ then key above the character:

280  **  Position numbers of cge characters (read down):

281  *          3 4 4 4 4 4 4 4 5 5 5 5 5 5 5
282  *          9 1 2 3 5 6 7 9 0 1 4 5 6 7 8

283  *lc1       a b c d e f g h i j k l m n o
284  *char      □
```

```
285  **  Position numbers of cge characters (read down):

286  *        1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
287  *        0 0 0 0 0 1 1 1 1 1 1 1 2 2 2
288  *        3 5 6 7 9 0 1 3 4 5 8 9 0 1 2

289  *lcl     a b c d e f g h i j k l m n o
290  *ucl     A B C D E F G H I J K L M N O
291  *char

292  ***          End of CGE Character listings.
     cgeind    cgeind            86          37      38      87         88        205
     cgeind1   cgeind           123         118
     cgeind2   cgestart          69         116
     cgeind3   cgestart          50          51     117
     cgeind4   cgestart          60         127
     cgestart  cgestart          33
     comment1  comment1         204
     comment2  comment1         213         218
     cont      cgeind           133         128
     cont1     cgestart          66          61
     instruct  cgestart          45          36
     new       cgeind           143          62     130
     old       cgeind           139          62     130
     quest1    quest1           149
     quest2    quest1           167
     quest3    quest1           181
     quest4    quest1           196
     skiper    cgestart          80
     back                       219
     key                        218
     nc                          62      62      62      62      64 130  65 130 129
                                130     130     130     131     132 145 132 145 140
                                145
     next                       218
     n1                         114     118     127     129     212     214     214
     n2                          35      36      61     115     116     117 128 124
     n21                         64      65     131     132     140     144
     n3                          23      24      62      64     125 130 126 131 126
     rstart1                     62      65
     station                     37      38     116     117
     user                        37      38

                                    lesson information

          lesson name = cgeindex

          starting date = 01/29/73

          last edited on 09/03/74 at 11.28.26

                    by neal of course eecge

                    at site 7, station 27
```

author name = J.P. Neal

department = EE

telephone number = 333-4351

discipline = EE

grade level = Freshman

descripion of lesson = The Router Lesson for Courses ee244 and eecge

```
                              lesson eex00 at 5:11 am on friday, september 6, 1974
--------------------------------------------------------------- part=1, block=a ----------


      block 1a,  eex00id

 stop
 ****    For Neal, CGERL, Room 248, EEB.

 One line description of this lesson --

    An Introduction to the CGE Station.

              Divisions of this Lesson:        Block    Unit

           Id for this file                    eex00id
           Experiment eex00;
              Description of cge station       x00m0a   x00m0a
              Conclusion                       x00m0g   x00m1a
           Cge s.r. and terms                  ck1-ck6

           Final edit 29 aug 74 neal.

 *list   info
 *list   symbols
 *list   varian,charset,cgeindex,cgechar
 ****
 start
 finish  endunit
 write   {at,1010} Loading the CGE Character Set
 charset cgeindex,cgechar
 erase
 dataon
 area    eex00
 ext     0

--------------------------------------------------------------- part=1, block=b ----------


      block 1b,  x00m0a


 unit    x00m0a
 erase
 name    n2
 next    x00m0a1
 help    x00s0a
 calcc   n30=400,n30⇐400,0
 jump    (n30=400),x00m0a1,x
 zero    n30
 at      304
 write      Hello {a,n2}

              This PLATO terminal is externally interfaced with the
```

```
        adjoining electronic experimentation equipment.

             At this CGE-PLATO station, PLATO can automatically
        determine the external interconnections between terminals
        of the experimentation equipment or check the settings
        of the dials on that equipment.

             This lesson will acquaint you with the uses of PLATO and
        the names of the panel controls and terminals of the
        instruments and circuit boards of the CGE station.

             Subsequent experiments will guide you to learn worthwhile
        methods for operating the electronic instruments and making
        electronic measurements.

             Experienced instructors have programmed connection
        checks and dial checks where necessary to sense your
        progress through the experiments and to provide you
        with additional assistance, if you seem to encounter
        undue difficulty or request help or information.

             If you are unacquainted with PLATO, press -HELP-,
        otherwise, press -NEXT-.
***
unit    x00m0a1
back    x00m0a
next    x00m0a2
zero    n30
at      1210
write        If you want to see a sample of the
        variety of lessons now programmed on PLATO,
        -TERM- sample. Otherwise, press -NEXT-.

***
unit    x00m0a2
back    x00m0a1
next    x00m0b
at      503
write        Now that you are acquainted with the Plato operation, you
        are ready to proceed with the Computer Guided Experiments.

             If you are somewhat familiar with electronic instruments
        or are exceptionally alert, you will find that you can
        rapidly accomplish the sequential learning tasks presented
        to you in the subsequent experiments.

             Do not be dismayed if you encounter difficulties.  If you
        have no difficulties and breeze through the tasks presented
        to you, you may be learning very little.

             As Alice in Wonderland said,
                "Oh, a knot!  Do let's untie it!"
----------------------------------------------------------- part=1, block=c ------------
```

```
block 1c,  x00m0b

unit      x00m0b
back      x00m0a
next      x00m0b1
name      n2
at        905
write        Hello again <a,n2>

             After this brief introduction you should be able to
          communicate with me and set the instruments in the
          "safe initial mode". This initial mode is specified
          and rechecked whenever you start a new experiment.
***

unit      x00m0b1
back      x00m0b
next      x00m0c
at        907
write        In front of you are five rack-mounted electronic
          instruments.

             Each instrument has a number of terminals between
          which you can make interconnections, and a number of
          knobs, switches, and dials by which you can adjust
          the instruments.

             I will list the names we use to refer to each of
          the instruments, terminals, and dials, and I suggest
          you locate each of them on the instrument panels.
***

unit      x00m0c
back      x00m0b1
next      x00m0c1
at        510
write       At the top left of the equipment rack is the
          Analab DUAL-TRACE SCOPE Type 1120. Note that red
          labels pertain to red knobs, and black labels
          pertain to black dials.

            Important dials of the SCOPE are:

          BEAM FINDER (a black dial)          SCALE
          INTENSITY (a red knob)              FOCUS
          A & B SEPARATION                    Power
          Y DISPLAY                           X DISPLAY
          Y POSITION                          X POSITION
***

unit      x00m0c1
back      x00m0c
next      x00m0d
at        506
write            To the right of the SCOPE, in the same frame,
             is the Analab TYPE 700 PLUG-IN.

                     Important dials of the PLUG-IN are:

             A VOLTS                 TIME                    B VOLTS

                            NULLs (red knobs)

             A PREAMP    TRIGGER SOURCE    SWEEP MODE    B PREAMP

                              TRIGGER SLOPE



                     Important terminals of the PLUG-IN are:

             A INPUT          TRIGGER INPUT         B INPUT
--------------------------------------------------------------------------- part=1, block=d ------------


          block 1d,  x00m0d


      unit      x00m0d
      back      x00m0c1
      next      x00m0d1
      at        505
      write        Directly below the SCOPE and the PLUG-IN is the
                FUNCTION GENERATOR:

                   On the FUN. GEN. there are:

                     Dials                         Terminals

                   TRIGGER                        SQUARE
                   MULTIPLIER                     TRIANGLE
                   CYCLES/SEC.                    SINE
                   OUTPUT (black knob)            RAMP
                   ATTENUATOR (red knob)          OUTPUT (red terminal)
                   DC LEVEL                       TRIG OUT
      ***

      unit      x00m0d1
      back      x00m0d
      next      x00m0e
      at        809
      write        Directly to the right of the PLUG-IN is
                the AUDIO OSCILLATOR.

                   The dials of the AUD. OSC. are:

                RANGE, Frequency, and AMPLITUDE.  The frequency dial
                is the large one in the center.
                The terminals of the AUD. OSC. are:

            GROUND (black), and the left and right red OUTPUT
            terminals.
     ***

     unit       x00m0e
     back       x00m0d1
     next       x00m0e1
     at         807
     write          Next to the AUD. OSC. is the VACUUM TUBE VOLTMETER.

                The RANGE dial is the only dial of the VTVM.

                INPUT terminals of the VTVM are red and black.

                OUTPUT terminals of the VTVM are red and black.

                In each case here, the black terminals are GROUND.
     ***

     unit       x00m0e1
     back       x00m0e
     next       x00m0g
     at         807
     write          The CONSTANT VOLTAGE/CONSTANT CURRENT or
                DC SUPPLY is located below the AUD. OSC. and the VTVM.

                    The dials of the DC SUP. are:

                METER, VOLTAGE, and CURRENT.

                    The terminals of the DC SUP. are:

                + (red), - (black), and GROUND.


                    Incidentally, the ground terminals of all of the
                instruments are interconnected at the power receptacles,
                so GROUND is essentially only one common terminal.
-------------------------------------------------------------- part=1, block=e --------


        block 1e,  x00m0g


     unit       x00m0g
     back       x00m0e1
     next       x00m0h
     lab        x00s0b
     at         807
     write          The CGE-PLATO system has the capability of
```

```
           automatically checking the interconnections between
           30 terminals and automatically checking the settings
           of 22 dials on the experimentation equipment.

              If you want to see a record of a present check,
           press -LAB-.

              Otherwise, press -NEXT-.
     ***

     unit    x00m0h
     join    inmodel

     entry   icheck
     join    inmodeck
     jump    n47,icheck,x00m1a
     ***

     unit    x00m1a
     back    x00m0h
     next    x00m1b
     name    n2
     at      807
     write      Hello again  ‹a,n2›

              At any time during an experiment, you can reach a
           slide display showing descriptions of the purposes of
           the important dials and terminals, the manufacturer'a
           specifications for the instruments, and other generally
           useful information by the -TERM- slides.

              You can do the experiments listed later in any order.

                 Consequently, if you attempt to perform the
           experiments out-of-sequence, and encounter too
           much difficulty, you may be automatically
           guided to stop your selected experiment and
           complete a prior-listed experiment, in order for
           you to learn how to properly use an instrument.

------------------------------------------------------------------ part=1, block=f ------------


        block 1f,  x00end


     unit    x00m1b
     next    x00end
     back    x00m1a
     at      609
     write     You are now ready to explore physical reality
           using this Computer-Guided Experimentation
           station.

               Leave all dials and connections in the safe
           initial mode, then press -NEXT- to go to the
```

```
            Index of Experiments.
***

unit    x00s0a
calc    n25⇐'eex00'
        n26⇐0
        n30⇐400
join    jmpmes
jumpout help
end
***

unit    x00s0b
base
back    x00m0g
next    x00s0c
join    rlm2b
***

unit    x00s0c
back    x00s0b
next    x00m0h
join    rlm4b
***

unit    x00end
course  n2
calcc   n2='ee244',
        nc(n21+1)⇐(nc(n21+1)$mask$o77777777770000000000)+o4603000000,
        nc(n21+1)⇐nc(n21+1)
course  n1
join    n1='ee244',endunit,x
join    jmpmes
jumpout cgeindex
***

unit    endunit
course  n2
jump    n2≠'ee244',leave,x
calc    nc(n21+7)⇐nc(n21+7)+ahelp
        vc(n21+6)⇐vc(n21+6)+atime/60000

entry   leave
***gives this lesson use of talk routines on cgerl
use     cgerl,rlm4b
use     rlm4c
use     rlm2b

 ------------------------------------------------------------------- part=1, block=g ----------


     block 1g,  ck1


unit    +cc
common  cgeindex,statlog,322
```

```
define  ckc
        cc=o40
        authorc=n33
        ccdata=n30
        bestcod=n36     $$ author code for best match
        besterr=n39     $$ number of errors in best match
        segment,acode=authorc,6
        segment,ccode=ccdata,6
        errors=n47
        print=n49       $$ -1=print off    0=print on
        start=n1
        search=n2
        termc=n3
        keytim=v4
        datac=n5
        count=n6
        acod1=n4
        acod2=n5
        ccod1=n6
        ccod2=n7
        state=n8

unit    ckcw
erase
calc    print⇐0
goto    cc1

unit    ckc
calc    print⇐-1
goto    cc1

unit    ckc1
calc    print⇐-1
goto    cc3

unit    ckc1w
erase
calc    print⇐0
goto    cc3

unit    cc1
******      Data Collection Routine.        *********
calc    n22⇐nc1⇐nc1+1
        n23⇐-1
mode    rewrite
do      ccmess
mode    write
pack    ccdata,++++++++++++++++++++++++++++++
calc    start⇐termc⇐1
        keytim⇐clock
        count⇐0
time    1
enable
ext     cc+termc

entry   cc1a
pause
```

```
goto    (key=timeup)-(key=micro$and$user='author'),cc1b,x,cc1out
goto    (key$mask$o1000)=0,cc1a,x  $$ throw out keyboard key
calc    keytim⇐clock
        datac⇐key$mask$o37
        count⇐count+1
calcc   termc=0,termc⇐1,termc⇐termc    $$stops array error
*       when hardware not turned on
goto    (datac=start)-(count>31),cc1c,x,cc1e
calc    ccode(termc)⇐start
        termc⇐datac
ext     cc+termc
goto    cc1a

unit    cc1c
calc    ccode(termc)⇐0
goto    termc=start,cc1d,x
calc    ccode(termc)⇐start
goto    cc1d

unit    cc1d
calc    start⇐start+1
        datac⇐ccode(start)
goto    ((datac≠"+")$and$(start≤30))-(start>30),cc1d,x,cc2
calc    termc⇐start
ext     cc+termc
goto    cc1a

unit    cc1b
time    1
goto    clock-keytim>1.5,x,cc1a
calc    keytim⇐clock
ext     cc+termc
goto    cc1a

unit    cc1e
*       Error if more than 30 keys recieved!!
mode    rewrite
at      3123
write   An Error Has Occurred!

unit    cc1out
calc    n22⇐nc1⇐nc1-1
pack    authorc,++++++++++++++++++++++++++++++
goto    cc2

unit    cc2
ext     0
disable
calc    besterr⇐100    $$init errors
mode    erase
do      ccmess
mode    write
goto    cc3

unit    cc3
calc    errors⇐0
        start⇐termc⇐0
```

```
do      cc4
goto    n23<0,x,skipc
goto    nc(322)<0,skipc,x
goto    n21<5$or$n21>310,skipc,x
calc    nc(n21+4)⇐nc(n21+4)+1
calcc   n47<0,nc(n21+5)⇐nc(n21+5)+1,nc(n21+5)⇐nc(n21+5)
zero    n23

entry   skipc
do      besterr+errors-1,x,cc9
exit    -print
do      cc8
exit    1
                                                              part=1, block=h -------------
---------------------------------------------------------------------------------------------
```

block 1h, ck2

```
unit    ckc2w
erase
calc    print⇐0
block   bestcod,authorc,3
goto    cc3

unit    ckc2
calc    print⇐-1
block   bestcod,authorc,3
goto    cc3

unit    cc4
calc    print⇐print    $$dummy calc to enter loop
1       start⇐start+1  $$next terminal number
        branch start>30,4,x              $$branch out when done
        ccod1⇐ccode(start)               $$get cc code
        acod1⇐acode(start)               $$get author code
        state⇐(ccod1=0$and$acod1="0")$or$(acod1="+")
        branch state,1,x
        search⇐start   $$set search at present terminal
                                          $$increment term. num.
2       search⇐search+1                   $$go away if too big
        branch search>30,1,x              $$get cc code
        ccod2⇐ccode(search)               $$get authors code
        acod2⇐acode(search)
        state⇐(acod1=acod2$and$acod1≠"0")
        state⇐state-2(ccod1=ccod2$and$ccod1≠0)-4(acod2="+")
        branch state,x,2,2,x,2
        errors⇐errors-1  $$add 1 to number of errors
        branch print,1,x
4       print⇐print    $$dummy calc to exit loop
goto    (start>30)-2((errors<-6)$and$print=0),cc5,x,cc6
at      581-200<errors
calc    term⇐start
do      cc7
writec  state, should be connected to ,*** man you are in trouble ***,
         shouldn't be connected to .
```

```
calc     termc⇐search
do       cc7
goto     cc4

unit     cc5
exit     1

unit     cc6
calc     errors⇐-7
at       521-200×errors
write    *** AND MORE ***
exit     1

unit     cc7
writec   termc,-,0,Term. 1,Term. 2,Term. 3,Term. 4,Term. 5,
         Term. 6,Term. 7,Term. 8,Term. 9,Term. 10,
         Term. 11,Term. 12,Ground,Term. 14,Term. 15,
         Scope: A volts,Scope: B volts,Scope: trigger,
         Fun-gen: sq. wave output,Fun-gen: triangle,
         Fun-gen: sine output,Fun-gen: ramp output,
         Fun-gen: attn'd output,Fun-gen: trigger out,
         DC supply:(+) ,DC supply(-),
         Aud-osc: right output,Aud-osc: left output,
         VTVM: input,VTVM: output,

unit     cc8
at       711-200n47
writec   errors,*** WIRING ERRORS *** (Press -NEXT-),,
exit     1

unit     cc9
block    authorc,bestcod,3
calc     besterr⇐-errors

unit     ccmess
at       3219
write    CONNECTION CHECK IN PROGRESS
------------------------------------------------------------- part=1, block=i ---------

        block 1i,  ck3

unit     +dc
define   ckd
         dc=o100
         authorc=n33
         dcdata=n30
         bestcod=n39      $$ author code for best match
         besterr=n44      $$ number of errors in best match
         segment,acode=authorc,6
         segment,dcode=dcdata,6
         errors=n47       $$ errors= -(number of errors found)
         print=n49        $$ -1=print off    0=print on
         dial=n1
```

```
                keytim=v2
                match=n3
                acod=n4
                dcod=n5
                imb=n16
                carrot=n17
                acod1=n18
                dcod1=n19
                state=n6
                paren=n7
                search=n8
                screen=n9

        unit    ckdw
        erase
        calc    print⇐0
        goto    dc

        unit    ckd
        calc    print⇐-1
        goto    dc

        unit    ckd1
        calc    print⇐-1
        goto    dc1

        unit    ckd1w
        calc    print⇐0
        erase
        goto    dc1

        unit    ckd2w
        erase
        block   bestcod,authorc,6
        calc    print⇐0
        goto    dc1

        unit    ckd2
        block   bestcod,authorc,6
        calc    print⇐-1
        goto    dc1

        unit    dc
        calc    n22⇐nc2⇐nc2+1
                n23⇐-1
        mode    rewrite
        do      dcmess
        calc    dial⇐1
                keytim⇐clock
        time    1
        enable
        ext     dc+dial

        entry   dc0
        pause
        goto    (key=timeup)-(key=micro$and$user='author'),dc0a,x,dcout
        goto    (key$mask$o1000)=0,dc0,x  $$throw out keyboard keys
```

```
calc     dcode(dial)⇐key$mask$o77
         dial⇐dial+1
         keytim⇐clock
goto     dial>22,dc0b,x
ext      dc+dial
goto     dc0

unit     dc0a
time     1
goto     clock-keytim<1.5,dc0,x
calc     keytim⇐clock
ext      dc+dial
goto     dc0

unit     dc0b
disable
ext      0
mode     erase
do       dcmess
mode     write
calc     besterr⇐1000   $$ init no. of errors in best match
goto     dc1

unit     dcout
calc     n22⇐nc2⇐nc2-1
pack     authorc,+++++++++·++++++++++++
calc     n36⇐n37⇐n38⇐0  $$fill out rest of authorc with blank
goto     dc0b

unit     dc1
calc     dial⇐search⇐paren⇐errors⇐0
         screen⇐310
do       dc2                          $$ go look for errors
goto     n23<0,x,skipd
goto     nc(322)<0,skipd,x
goto     n21<5$or$n21>310,skipd,x
calc     nc(n21+2)⇐nc(n21+2)+1
calcc    n47<0,nc(n21+3)⇐nc(n21+3)+1,nc(n21+3)⇐nc(n21+3)
zero     n23

entry    skipd
do       besterr+errors-1,x,dc5    $$ is this a best match?
exit       (print=0)
exit     1

unit     dc3
at       screen-1
write    These dials are incorrectly set
draw     309;349
calc     screen⇐screen+300

---------------------------------------------------------------- part=1, block=j ----------
```

block 1j, ck4

```
unit    dc2
calc    print⇐print       $$dummy calc to enter loop
1       dial⇐dial+1
        match⇐0           $$ set no match  found yet flag
        branch dial>22,999,x
        dcod⇐dcode(dial)
100     search⇐search+1                 $$ incr author loc.
        acod⇐acode(search)              $$ get author coue
        state⇐(acod="(")-(acod=")")-2(acod="+")-3(acod="<")-4(acod=">")
        branch state,400,x,300,1,600,500
        branch carrot,700,x
        match⇐match+(acod=dcod)          $$ check for match
        branch paren,100,x             $$ branch for paren loop
        branch match,1,900               $$ was there a match?
300     paren⇐0           $$ clear paren loop flag
        branch match,1,900               $$ was there a match?
400     paren⇐-1          $$ set paren loop flag
        branch 100        $$ go look at next author code
500     carrot⇐0
        branch match,1,900
600     carrot⇐-1
        dial⇐dial+1
        dcod1⇐dcode(dial)
        branch 100
700     imb⇐0
800     search⇐search+1
        acod1⇐acode(search)
        imb⇐imb+(acod1="(")-(acod1=")")
        match⇐match+(acod=dcod$and$acod1=dcod1)
        branch imb,800,100,100
900     errors⇐errors+1                  $$ add to error count
        branch print,1,x                 $$ should we print?
999     print⇐print       $$ dummy calc to exit loop
exit    -(dial>22)        $$ quit when done
do      screen=310,dc3,x
goto    screen>2000,dc4,x
at      screen
writec  (dial-11)/3,Oscilloscope,Function generator,
        Function generator,DC power supply,
        Audio oscillator,Vacuum tube voltmeter,
write
writec  dial...B volts, time,A volts,B preamp,
        sweep mode,trigger source,A preamp,
        Y display func,X display func,
        trigger,multiplier,cycles/sec,
        output,attenuator,DC level,meter,
        voltage,current,amplitude,
        range,frequency,range,
write   .
calc    screen⇐screen+200
goto    dc2

unit    dc4
at      screen+100
write   *** AND MORE ***
```

```
unit    dc5
block   authorc,bestcod,6
calc    besterr⇐abs(errors)

unit    dcmess
at      3223
write   DIAL CHECK IN PROGRESS

----------------------------------------------------------------- part=1, block=k ---------


        block 1k,  ck5


unit    comment
term    comment
dataon
erase
at      510
write   Please type your comment at the arrow.

        Press -NEXT- to enter another line of comment.
        Press -BACK- when finished.
calc    n1⇐1110

entry   comment1
arrow   n1⇐n1+100
jkey    back
ok
endarrow
goto    key=next,comment1,x
press   back

unit    sample
term    sample
at      710
write   Now returning you to SAMPLE!
inhibit jumpchk
jumpout sample

unit    cgerl
term    cgerl
do      jmpmes
jumpout cgerl

unit    index
term    index
do      jmpmes
jumpout cgeindex,cgeind

unit    jmpmes
write   ⟨at,1516⟩One moment please
inhibit jumpchk

unit    inmodeck
pack    n33,+++cfhe++a+++a(abcd)+a(ab)a++l
```

```
join    ckd
join    n47,inmode,x
join    n47,x,inmodec

unit    inmodec
pack    n33,000000000000a00000000000000a00
join    ckcw
join    n47,inmodep,x

unit    inmodep
pause   .5
pause

unit    inmode
erase
at      1210
write    The equipment was not set in the initial mode.
pause   1.5
erase

entry   inmode1
term    imode
at      109
write   Please:   Remove all plugged-in connections
                  Securely fasten all ground links
                  Set the dials in this safe initial mode:

                   SCOPE:
                      INTENSITY         fully CCW

                   PLUG-IN:
                      NULLS             at zero
                      A and B PREAMPs OFF
                      TRIGGER SOURCE  OFF
                      SWEEP MODE        OFF

                   FUN GEN:
                      TRIGGER           INT
                      ATTENUATOR        fully CCW
                      DC LEVEL          CCW and click

                   AUD OSC:
                      AMPLITUDE         zero

                   DC SUPPLY:
                      VOLTAGE           0
                      CURRENT           0

                   VTVM:
                      RANGE             300

                   ALL POWER SWITCHES ON

        When ready to proceed, press +NEXT-.
pause   .5
pause
```

```
unit      imode
erase
at        1007
write        Before proceeding, please return the equipment to
          the Safe Initial Mode.
pause
join      inmodeck
exit
```

```
----------------------------------------------------------- part=1, block=1 ---------
```

```
     block 11,  ck6

unit      slides
next      slide1
term      slides
erase
calcc     (station=251),n101⇐256,256
slide     n101
at        207
write     SLIDE NO.       CGE SLIDE

            1          CGERL Entrance
            2          The EE244 Laboratory
            3          The CGE-PLATO System Description
            4          Orientation of the CGE Station
            7          Layout of Sensed Dials and Terminals
            8          List of Sensed Dials and Terminals
            19         Resistor Color Code
            20 - 21    E E Symbols and Units
            22         Recommended Unit Prefixes
            23         Defined Physical Values
            24 - 26    Physical Constants
            27 - 32    SCOPE -    Use of Dials and Terminals
            33 - 35    SCOPE -    Manufacturer's Specifications
            36 - 44    PLUG-IN -  Use of Dials and Terminals
            45 - 50    PLUG-IN -  Manufacturer's Specifications
            51 - 53    FUN.GEN. - Use of Dials and Terminals
            54 - 56    FUN.GEN. - Manufacturer's Specifications
            57 - 60    AUD.OSC. - Use of Dials and Terminals
            61 - 62    AUD.OSC. - Manufacturer's Specifications
            63 - 66    VTVM -     Use of Dials and Terminals
            67 - 68    VTVM -     Manufacturer's Specifications
            69 - 71    DC SUPP -  Use of Dials and Terminals
            72 - 75    DC SUPP -  Manufacturer's Specifications
            76         Graph of a Transient
            95         CGE-PLATO Interface.

          Type slide no.       ,press -NEXT-, or -BACK- to return.
arrow     3021
store     n100
ok
erase
goto      (n100<96),slide1,slideno
```

```
754  ***

755  unit     slideno
756  back     slides
757  next     slides
758  at       1210
759  write    NO!  Type  a number less than 96.
760  ***

761  unit     slide3
762  slide    n100+512
763  ***

764  unit     slide1
765  back     slides
766  next     slide2
767  at       3204
768  write       This is slide <z,n100>.  Press -NEXT- for next slide
769  slide    n100
770  ***

771  unit     slide2
772  back     slides
773  next     slides
774  calc     n100⇐n100+1
775  goto     (n100≤96),slide1,x
776  slide    512
777  at       1210
778  write    You can't show a slide greater than 96.
     comess     ck2              455              319     374
     cc1        ck1              314              303     306
     cc1a       ck1              328              331     341     353     356     359
     cc1b       ck1              354              330
     cc1c       ck1              342              337
     cc1d       ck1              347              344     346     350
     cc1e       ck1              360              337
     cc1out     ck1              365              330
     cc2        ck1              369              350     368
     cc3        ck1              377              309     313     376     397     401
     cc4        ck2              402              380     429
     cc5        ck2              430              421
     cc6        ck2              432              421
     cc7        ck2              437              424     428
     cc8        ck2              448              390
     cc9        ck2              452              388
     cgerl      ck5              649
     ckc        ck1              304
     ckcw       ck1              300              667
     ckc1       ck1              307
     ckc1w      ck1              310
     ckc2       ck2              398
     ckc2w      ck2              393
     ckd        ck3              487              662
     ckdw       ck3              483
     ckd1       ck3              490
     ckd1w      ck3              493
     ckd2       ck3              502
```

```
ckd2w      ck3            497
comment    ck5            626
comment1   ck5            636       641
dc         ck3            506       486     489
dcmess     ck4            622       510     536
dcout      ck3            540       518
dc0        ck3            516       519     525     528     531
dc0a       ck3            526       518
dc0b       ck3            532       523     544
dc1        ck3            545       492     496     501     505     539
dc2        ck4            565       548     615
dc3        ck3            559       599
dc4        ck4            616       600
dc5        ck4            619       556
endunit    x00end         266       18      262
icheck     x00m0g         203       205
imode      ck5            706
index      ck5            653
inmode     ck5            672       663
inmodec    ck5            665       664
inmodeck   ck5            660       204     712
inmodep    ck5            669       668
inmode1    ck5            678       202
jmpmes     ck5            657       241     263     651     655
leave      x00end         271       268
rlm2b         not found             249
rlm4b         not found             254
sample     ck5            643
skipc      ck1            387       381     382     383
skipd      ck3            555       549     550     551
slideno    ck6            755       753
slides     ck6            715       756     757     765     772     773
slide1     ck6            764       716     753     775
slide2     ck6            771       766
slide3     ck6            761
x00end     x00end         256       227
x00m0a     x00m0a         26        57      82
x00m0a1    x00m0a         56        29      32      66
x00m0a2    x00m0a         65        58
x00m0b     x00m0b         81        67      93
x00m0b1    x00m0b         92        83      107
x00m0c     x00m0b         106       94      122
x00m0c1    x00m0b         121       108     136
x00m0d     x00m0d         135       123     151
x00m0d1    x00m0d         150       137     164
x00m0e     x00m0d         163       152     174
x00m0e1    x00m0d         173       165     188
x00m0g     x00m0g         187       175     247
x00m0h     x00m0g         201       189     208     253
x00m1a     x00m0g         207       205     228
x00m1b     x00end         226       209
x00s0a     x00end         237       30
x00s0b     x00end         245       190     252
x00s0c     x00end         251       248
+cc        ck1            277
+dc        ck3            459
abs          ckd          621
```

```
acod     ckd     473   572   573   573   573   573   573  593
acode    ckc     285   407   414
acode    ckd     466   572   591
acod1    ckc     295   407   408   408   415   415
acod1    ckd     477   591   592   592   593
acod2    ckc     296   414   415   416
ahelp    ckc     269
atime    ckc     270
authorc  ckc     281   285   367   396   400   453
authorc  ckd     462   466   499   503   542   620
back     ckd     642
bestcod  ckc     283   396   400   453
bestcod  ckd     464   499   503   620
besterr  ckc     284   372   388   454
besterr  ckd     465   538   556   621
carrot   ckd     476   575   583   585
cc       ckc     280   327   340   352   358
ccdata   ckc     282   286   321
ccode    ckc     286   338   343   345   349   406   413
ccod1    ckc     297   406   408   416   416
ccod2    ckc     298   413   416
clock    ckc     323   332   356   357
clock    ckd     512   522   528   529
count    ckc     294   324   334   334   337
datac    ckc     293   333   337   339   349   350
dc       ckd     461   515   524   530
dcdata   ckd     463   467
dcod     ckd     474   570   576   593
dcode    ckd     467   520   570   587
dcod1    ckd     478   587   593
dial     ckd     470   511   515   520   521   521   523  534
                 546   567   567   569   570   586   586  548
                 602   606
errors   ckc     287   378   388   418   418   421   422  434
                 450   454
errors   ckd     468   546   556   595   595   621
imb      ckd     475   589   592   592   594
key      ckc     330   330   331   333
key      ckd     518   518   519   520   641
keytim   ckc     292   323   332   356   357
keytim   ckd     471   512   522   528   529
match    ckd     472   568   576   576   578   580   584  543
micro    ckc     330
micro    ckd     518
nc       ckc     259   259   260   260   269   269   382  384
                 385   385   385   385
nc       ckd     550   552   552   553   553   553   553
nc1      ckc     316   316   366   366
nc2      ckd     507   507   541   541
next     ckd     641
n1       ckc     261   262   289
n1       ckd     470   635   637   637
n100     ckd     750   753   762   768   769   774   774
n101     ckd     719   720
n16      ckd     475
n17      ckd     476
n18      ckd     477
```

```
n19         ckd          478
n2          ckc           28     35     84     86    210    212    257  267
                         268    290
n21         ckc          259    259    260    260    269    269    270  383
                         383    384    384    385    385    385    385
n21         ckd          551    551    552    552    553    553    553
n22         ckc          316    366
n22         ckd          507    541
n23         ckc          317    381    386
n23         ckd          508    549    554
n25         ckc          238
n26         ckc          239
n3          ckc          291
n3          ckd          472
n30         ckc           31     31     32     33     59    240    282
n30         ckd          463
n33         ckc          281
n33         ckd          462    661    666
n36         ckc          283
n36         ckd          543
n37         ckd          543
n38         ckd          543
n39         ckc          284
n39         ckd          464
n4          ckc          295
n4          ckd          473
n44         ckd          465
n47         ckc          205    287    385    449
n47         ckd          468    553    663    664    668
n49         ckc          288
n49         ckd          469
n5          ckc          293    296
n5          ckd          474
n6          ckc          294    297
n6          ckd          479
n7          ckc          298
n7          ckd          480
n8          ckc          299
n8          ckd          481
n9          ckd          482
paren       ckd          480    546    577    579    581
print       ckc          288    302    305    308    312    389    395  483
                         403    419    420    420    421
print       ckd          469    485    488    491    494    500    504  566
                         566    596    597    597
screen      ckd          482    547    560    563    563    599    600  614
                         614    617
search      ckc          290    410    411    411    412    413    414
search      ckd          481    546    571    571    572    590    590
segment     ckc          285    286
segment     ckd          466    467
start       ckc          289    322    337    338    344    345    348  349
                         350    350    351    379    404    404    405  407
                         410    421    423
state       ckc          299    408    409    415    416    416    417
state       ckd          479    573    574
station     ckd          719
```

```
termc      ckc     291    322    327    335    335    335    335   339
                   340    343    344    345    351    352    358   423
timeup     ckc     427    438
timeup     ckd     330
user       ckc     518
user       ckd     330
vc         ckc     518
v2         ckd     270    270
v4         ckc     471
                   292
```

lesson information

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by borth of course eecge

at site 7, station 27

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discipline = elect. engr. lab

grade level = Freshman

descripion of lesson = An Introduction to the CGE Station

```
                      lesson eex01 at 2:23 am on tuesday, august 27, 1974

----------------------------------------------------------------- part=1, block=a -----------


      block 1a,  eex01id

stop
****    For Neal, CGERL, Room 248, EEB.

One line description of this lesson --

   The Operation and Uses of the Oscilloscope, Analab 1120.

              Divisions of this Lesson:       Block    Unit

          Id for this file                    eex01id
          Experiment eex01;
            Objectives                        x01m0a   x01m0a
            Find crt spot                     x01m1a   x01m1a
            Measure constant v                x01m2a   x01m2a
            Measure v                         x01m3a   x01m3a
            Use null dials                    x01m4a   x01m4a
            Display 2 voltages                x01m5a   x01m5a
            Lissajous figure                  x01m5a   x01m6a
            Final test                        x01m7a   x01m7a

          final edit 21 aug 74 neal.

*list   info
*list   symbols
*list   varian,charset,cgeindex,cgechar
****
start
finish  endunit
write   «at,1010» Loading the CGE Character Set
charset cgeindex,cgechar
erase
dataon
area    eex01
ext     0

----------------------------------------------------------------- part=1, block=b -----------


      block 1b,  x01m0a


unit    x01m0a
restart
base
next    x01m1a
join    imode
jump    n47,x01m0a,x
erase
```

```
at      508
write     THE OPERATION and USES of the OSCILLOSCOPE.

               ANALAB DUAL TRACE SCOPE TYPE 1120

                  with TYPE 700 PLUG-IN



             When you have completed this experiment
        you should be able to :

          1) Find and Adjust a Spot on the CRT Screen.

          2) Measure Constant Voltages.

          3) Measure Time-Varying Voltages.

          4) Use the NULL dials.

          5) Display Two Voltages vs Time simultaneously.

          6) Display a Lissajous Figure.
------------------------------------------------------------------ part=1, block=c ------------


      block 1c.  x01m1a


unit    x01m1a
base
erase
back    x01m0a
next    x01m1b
help    x01s1a
at      1010
write      Find the spot on the screen and position it at
        (0,0), i.e., the center of the CRT screen.


           CAUTION: Keep the INTENSITY only as high as
        you need to see the spot. Otherwise, damage to
        the screen may occur.
at      2820
write      -HELP- is available.
***

unit    x01m1b
base
back    x01m1a
next    x01m1c
help    x01s1a
at      1405
write      The spot should be a sharp point of light with no halo.
```

```
                 If it is not, adjust the INTENSITY and FOCUS
              controls to correct the condition of your spot.
     at       3020
     write       -HELP- is available.
     ***

     unit     x01m1c
     restart
     base
     back     x01m1b
     next     x01m1c1
     lab      x01s1d
     help     x01s1g
     at       1210
     write          Now that the spot is centered, balance the
              A PRE AMP before proceeding. Press -LAB- for an
              explanation of the PRE AMP Balancing Procedure.

                 When you have verified the balance of the A PRE
              AMP, set the dials so the spot will be deflected
              5 cm when a voltage of ± 10 volts is applied
              to the A INPUT of the SCOPE.
     at       3020
     write       -HELP- is available.
     ***

     unit     x01m1c1
     pack     n33,++n+fh(cd) (ae)++++++++++++++
     join     ckd
     jump     n47,x,x01m2a,x
     pack     n33,++++++(cd)+++++++++++++++
     join     ckd1
     jump     n47,x01s1i,x01s1f

 ------------------------------------------------------------ part=1, block=d ----------


          block 1d,  x01m2a


     unit     x01m2a
     back     x01m1c
     next     x01m2a1
     help     x01s2a
     at       1007
     write       Great!   You correctly set the dials.

                 Now, make connections and dial settings so you can
              display the voltage from the DC Supply on the A channel
              of the SCOPE.  A positive voltage  should cause an
              upward deflecton.

                 As usual, press -NEXT- when you finish.
```

```
                      -HELP- is available.
***

unit    x01m2a1
jump    user='author'$and$station≠251,x01m2b,x
pack    n33,++++++++++++a++b00000000ba0+00
join    ckc
jump    n47,x01m2a2,x01m2a3
***

unit    x01m2a2
pack    n33,++++++++++++a++b00000000ab0+00
join    ckc1
jump    n47,x01s2a,x01m2a4
***

unit    x01m2a3
pack    n33,++n+fh+(ae)(ab)+++++++++++++
join    ckd
jump    n47,x01s2a1,x
pack    n33,++++++c+++++++++++++++
join    ckd1
jump    n47,x01s2b,x01m2b
***

unit    x01m2a4
pack    n33,++n+fh+(ae)(ab)+++++++++++++
join    ckd
jump    n47,x01s2a1,x
pack    n33,++++++d+++++++++++++++
join    ckd1
jump    n47,x01s2b,x01m2b
***

unit    x01m2b
back    x01m2a
next    x01m2b1
at      1207
write      Without changing anything on the SCOPE, deflect
        the spot to Y = 5 cm.

           HINT. To make the DC Supply function properly,
        you must set the CURRENT dial to about 100 ma then,
        adjust the VOLTAGE dial until the 5 cm deflection
        is achieved.
***

unit    x01m2b1
pack    n33,++n+fh(cd)(ae)++++++++(def)(bcdefghijklmnopqrstuv)++++
join    ckd
jump    n47,x01s2c,x01m2c
***

unit    x01m2c
back    x01m2b
next    x01m2d
at      1210
```

```
write      Observe the effects of the A PREAMP control.

              How many centimeters deflection do you get
           using the AC settings?
arrow      1635
answer     (zero,0)
at         1810
write         The AC refers to the type of coupling. AC coupling
           implies that there is a capacitor in the input circuit,
           to block the dc or average component.
no
at         1810
write         If the spot is not at 0 you have done something
           wrong. Check your balancing again, and if that
           doesn't help call your instructor.


---------------------------------------------------------------- part=1, block=e ---------


      block 1e,  x01m2d


unit       x01m2d
base
back       x01m2c
next       x01m2d1
lab        x01s1e
help       x01s2d
at         1207
write         Similarly, the spot can be deflected horizontally.

              Balance the B PRE AMP, if you have not done so. You
           may review the balancing procedure by pressing -LAB-.

              Set the dials and make the connections necessary
           to deflect the spot 4 cm horizontally when a voltage
           of +8 volts is applied the B INPUT of the SCOPE. The
           Y DISPLAY must be set to A vs B.

              Set the B PRE AMP to DC+.

***

unit       x01m2d1
pack       n33,n++(cd) fh(cd) +++++++++ (bcd) (bcdefghijklmnopqrstuv)++++
join       ckd
jump       n47,x01m2d3,x01m2d2
***

unit       x01m2d2
pack       n33,000000000000g000a0000000ag0+00
join       ckc
jump       n47,x01s2e,x01m2e
***
```

```
unit    x01m2d3
pack    n33,n++(cd)fhe+++++++++(bcd)(bcdefghijklmnopqrstuv)++++
join    ckd1
jump    n47,x01s2e,x
pack    n33,000000000000g00+a0000000ag0+00
join    ckc
jump    n47,x01s2e,x01m2e
***

unit    x01m2e
back    x01m2d
next    x01m2e1
at      507
write        Without changing A VOLTS or B VOLTS dials,
        deflect the spot to:

                              X=3cm    Y=3cm

            Try to do this and then press -NEXT-, as always.
        You will be guided automatically if you have difficulty.
***

unit    x01m2e1
jump    user='author'$and$station=251,x01m2f,x
pack    n33,n+n(cd)++(cd)e+++++++++(bcd)(bcdefghijklmnopqrstuv)++++
join    ckd
jump    n47,x,x01m2e2
pack    n33,++++++++++++++++(bcd)(bcdefghijklmnopqrstuv)++++
join    ckd1
jump    n47,x01s2g,x01s2f
***

unit    x01m2e2
pack    n33,+++c++c+++++++++++++++
join    ckd1
calcs   n47,n70⇒0,-1
pack    n33,++++++++++++a++bb0100000ba0+00
join    ckc
jump    n47,x01m2e3,x
jump    n70,x01m2f,x01s2h
***

unit    x01m2e3
pack    n33,++++++++++++a++bb0000000ab0+00
join    ckc1
jump    n47,x01s2i,x
jump    n70,x01s2h,x01m2f
***

unit    x01m2f
back    x01m2e
next    x01m3a
at      710
write      GOOD!

           Do not change the dial settings on the SCOPE.
```

```
            Observe the effect of varying the VOLTAGE control
         of the DC SUPPLY.

--------------------------------------------------------------------- part=1, block=f ---------


     block 1f,  x01m3a


unit     x01m3a
restart
base
back     x01m2f
next     x01m3a1
help     x01s3a
at       507
write       Apply a 20 Hz signal, with a peak-to-peak voltage
         of Vp-p = 12 V, from the AUDIO OSCILLATOR  to the
         A channel of the SCOPE.
at       3020
write    -HELP- is available
***

unit     x01m3a1
pack     n33,++++++++++++g++a0000000000ag00
join     cko
jump     n47,x01s3d,x01m3a2
***

unit     x01m3a2
pack     n33,++n+fh(cd)e++++++++++(cd)a(bc)+
join     ckd                $$ Performs a complete dial check
jump     n47,x,x01m3b       $$ Jumps, if dial check correct
pack     n33,++n+fh(cd)e++++++++++++++
join     ckd1               $$ Checks PLUG-IN and SCOPE dials
jump     n47,x01s3e,x       $$ Help provided if incorrect
pack     n33,++++++++++++++++++++a(bc)+
join     ckd1               $$ Check the frequency dial setting
jump     n47,x01s3f,x       $$ Help provided if incorrect
pack     n33,++++++++++++++++++(cd)+++
join     ckd1               $$ Checks the DC SUPPLY settings
jump     x01s3g             $$ Help provided if incorrect
***

unit     x01m3b
back     x01m3a
next     x01m3c
at       510
write       Now, what do you see displayed on the SCOPE ?
arrow    710
answer   <a,an,beautiful,clear,vertical,straight>line
at       1010
write    That's right. The dot is being deflected up and down
         sinusoidally.  But it's moving so fast that it
```

```
                 appears as a vertical line.
      no
      at         1010
      write      You should see a vertical line.
                 If you don't, press -BACK- to go through
                 this section again.
      ***

      unit       x01m3c
      back       x01m3b
      next       x01m3c1
      help       x01s3h
      at         910
      write         In order to make this waveform appear
                 on the SCOPE as a sine wave, it is
                 necessary to sweep the display horizontally.

                    To do this, you must apply a periodic
                 linearly-increasing voltage to the SCOPE's
                 horizontal input for a timed sweep.

                    Turn the A PRE-AMP to OFF and apply a 0.9 Hz
                 non-adjustable RAMP wave from the FUNCTION
                 GENERATOR to the B INPUT of the SCOPE.

                    Set B VOLTS to 50 V.
      at         3020
      write      -HELP- is available.

 ---------------------------------------------------------------- part=1, block=g ------------


            block 1g,  x01m3c1


      unit       x01m3c1
      pack       n33,c+ncfhee+ac(rst)++(abcde)+++(cd)a(bc)+
      join       ckd
      jump       n47,x01s3i,x01m3c2
      ***

      unit       x01m3c2
      pack       n33,++++++++++++g++ab0000b0000ag00
      join       ckc
      jump       n47,x,x01m3d
      pack       n33,++++++++++++g++a+++++++++++ag++
      join       ckd1
      jump       n47,x01s3j,x
      at         1410
      write            You did not apply the non-adjustable
                 RAMP wave correctly!
      pause
      jump       x01m3c
      ***

      unit       x01m3d
```

```
back     x01m3c
next     x01m3d1
at       510
write       As you see, this makes the spot sweep across
         the screen as a linear function of time.

            Now, set the A PRE AMP to DC+ and the FUNCTION
         GENERATOR to 9 Hz.
***

unit     x01m3d1
pack     n33,o+ncfhce+ad(rst)++(abcde)+++++++
join     ckd
jump     n47,x,x01m3e
at       1410
write         Read the problem carefully!!!  You
         were given only two dials to change.
pause
jump     x01m3d
***

unit     x01m3e
base
back     x01m3d
next     x01m3e1
help     x01s3k
at       307
write       Good! You should now have a sine wave
         displayed on the screen.
            However, there are 2 things wrong with this display:

            1) There is a visible retrace when the spot
         comes quickly back to the left.

            2) The display is not stable.

            To solve the first problem:

         The SWEEP system of the SCOPE can be used to internally
         generate a ramp wave and blank out the return trace.

            To solve the second problem:

         The TRIGGER SOURCE of the SCOPE can automatically
         start the SWEEP at the beginning of each period.


            Make the necessary adjustments to solve both these
         problems, and remove any unnecessary connections.
at       3020
write    -HELP- is available.
***

unit     x01m3e1
pack     n33,++n++(fg)+a+++++++++++(cd)a(bc)+
join     ckd
jump     n47,x01s31,x
```

```
pack     n33,++++++++++++g++a0000000000ag00
join     ckc
jump     n47,x01s3m,x01m4a

------------------------------------------------------------------ part=1, block=h ------------


       block 1h,  x01m4a'


unit     x01m4a
restart
join     imode
jump     n47,x01m4a,x01m4a0
***

unit     x01m4a0
base
back     x01m3e
next     x01m4a1
help     x01s4a
at       507
write       Display on the A channel of the SCOPE, a
         nonadjustable SINE wave having a frequency of
         200 Hertz from the FUNCTION Generator.

            Externally trigger the SCOPE from the FUNCTION
         GENERATOR.


                    -HELP- is available.
***

unit     x01m4a1
pack     n33,+++++++++++++++a+b00a00b000+00
join     ckcw
next     n47,x01m4a0,x
jump     n47,x,x01m4a2
***

unit     x01m4a2
pack     n33,++++(cd) (de) (abdc) abaf (bcd)++++++++++
join     ckdw
next     n47,x01m4a0,x
jump     n47,x,x01m4b0
***

unit     x01m4b0
next     x01m4b
back     x01m4a
at       1210
write    Leave this waveform on the screen.  You will
         need it again later on.
***

unit     x01m4b
```

```
base
back    x01m4a
next    x01m4c
help    x01s4b
zero    n70
at      1207
write      The NULL dials, with the TIME and the A and B
        VOLTS dials, can be used in measuring values on the
        CRT display.  For this use, the NULL dials must be
        set at zero initially.

           The value of a voltage point is measured by
        rotating the associated NULL dial until the voltage
        point being measured is returned to the zero voltage
        level of the display.  The manner in which the value
        of the voltage is read will be discussed when you
        press -NEXT-.

           Press -HELP- if you do not understand the meaning
        of the phrase 'zero voltage level'.
***

unit    x01m4c
circle  144,248,256
circle  40,248,256
at      237,368
size    1
write   0.0

        0.0

        0.0
size    1
rotate  -90
at      358,269
write    2.0
at      328,270
write    0.8
at      299,270
write    0.4
rotate  180
at      256,198
write   0.8
at      256,167
write   1.6
at      256,137
write   4.0
draw    1632;skip;1632
draw    192,389;134,447;skip;305,387;364,446
circle  212,248,268,57,122
draw    730;215,417;skip;734;275,419
circle  116,233,303,99,119
circle  124,260,296,83,61
circle  174,247,275,121,58
rotate  0
calc    n70⇐0
at      243,403
```

```
write    V
goto     x01m4d
rotate   0
size     0

 ---------------------------------------------------------------- part=1, block=i ----------


         block 1i,  x01m4d!


unit     x01m4d
calc     n70⇐n70+1
jump     (n70=4),x01m4e,x,x
mode     erase
at       235,424
writec   n70,,,, 1, 2 .
mode     write
at       235,424
writec   n70,,, 1, 2, 5
rotate   180
join     n70,x,x,x01m4d1,x01m4d2,x01m4d3
rotate   0
size     0
mode     erase
join     n70,x,x,x,x01m4d4,x01m4d5
mode     write
join     n70,x,x,x01m4d4,x01m4d5,x01m4d6
size     1
pause
goto     x01m4d
***

unit     x01m4d1
at       222,312
write    ✧
***

unit     x01m4d2
mode     erase
at       222,312
write    ✧
mode     write
at       222,344
write    ✧
***

unit     x01m4d3
mode     erase
at       222,344
write    ✧
mode     write
at       222,375
write    ✧
***
```

```
unit      x01m4d4
at        2810
write        When either the A or B VOLTS dial is set at
          1, 10, or 100, read the NULL on the bottom scale.
***   :

unit      x01m4d5
at        2810
write        When the A or B VOLTS dial is set at
          2, 20, or 200, read the NULL on the middle scale.
***   :

unit      x01m4d6
at        2810
write        When the A or B VOLTS dial is set
          5, 50, or 500, read the NULL on the top scale.
***   :

unit      x01m4e
next      x01m4f
size      0
at        1410
write        Now that you know what scale to read on the NULL
          dial, you can measure a voltage point by taking the
          reading on the NULL and moving the decimal point
          to the right by the number of zeros in the number
          displayed in the FULL SCALE window.
***   :

unit      x01m4f
back      x01m4b
next      x01m4g
at        1210
write        If the A VOLTS dial was set at 100 mV and
          the NULL reading was .5 , what would be the voltage ?

                a.)     5 mV
                b.)     50 V
                c.)     50 mV
                d.)     500 mV
arrow     2215
specs     bumpshift
answer    c
wrong     b
at        2410
write           The answer is in mV not V.
wrong      (a,d)
at        2410
write           There are two zero's in the A Volts
          reading, and 10^2×.5=50.
***   :

unit      x01m4g
next      x01m5a
back      x01m4f
help      x01m4b
pack      n33,+++++++++++++++a+b00a00b000+00
```

```
join    ckc
jump    n47,x01s4c,x
pack    n33,++++(cd)(de)(abdclabaf(bcd)++++++++++
join    ckd
jump    n47,x01s4c,x
at      1308
write      Measure the peak-peak voltage of the sine wave
        displayed on the Scope using the A VOLTS NULL DIAL.

           What is the measured voltage          volts
arrow   1640
ansv    41,10

------------------------------------------------------------ part=1, block=j ---------


     block 1j.  x01m5a


unit    x01m5a
restart
join    imode
jump    n47,x01m5a,x01m5a0
***  :

unit    x01m5a0
base
back    x01m4f
next    x01m5a1
lab     x01s1e
at      910
write      This oscilloscope is capable of displaying two
        waveforms at the same time, which is very useful
        in comparison measurements.

           Using the FUNCTION GENERATOR, apply a nonadjustable
        SINE wave to channel A and a nonadjustable SQUARE
        wave to channel B of the SCOPE.

           Trigger the SCOPE from the FUNCTION GENERATOR.

           Each time you begin a new series of measurements,
        it is advisable to recheck the dc balance of the
        A and B PRE AMPs, and rezero the traces.

           Press -LAB- to review the balancing procedure.
***  :

unit    x01m5a1
pack    n33,+++++++++++++++abcb0a00c000+00
join    ckcw
next    n47,x01m5a0,x
jump    n47,x,x01m5b
***  :

unit    x01m5b
```

```
back     x01m5a0
next     x01m5b1
at       510
write       Set the frequency at 40 Hertz, and display
         both traces simultaneously, with TIME FULL SCALE
         at 100 ms.
***  :

unit     x01m5b1
pack     n33,+m+(abcd)(cd)(de)(abcd)cbae(ghi)++(abcd)+++++++
join     ckdw
jump     n47,x,x01m5c
next     x01m5b
***  :

unit     x01m5c
back     x01m5b
next     x01m5d
at       1207
write       For the most stable display of a low frequency
         signal the CHOP setting of the Y DISPLAY is desirable.
***  :

unit     x01m5d
back     x01m5c
next     x01m6a
at       1210
write       Experiment on your own for awhile.  Change
         the frequency of the wave and the TIME dial.

            Note which setting of the Y DISPLAY (ALT or CHOP)
         gives the best display.
***  :

unit     x01m6a
back     x01m5d
next     x01m7a
at       1214
write       Set the Y DISPLAY FUNCTION to A vs B.
pause
pack     n33,+++++++e++++++++++++++
join     ckd
jump     n47,x01s6a,x
at       1610
write       The pattern you see on the SCOPE is called
         a LISSAJOUS figure.  Change the wave INPUTS to
         the SCOPE (SQUARE,SINE,TRIANGLE,RAMP) to get
         different patterns.

------------------------------------------------------------ part=1, block=k ---------


     block 1k,  x01m7a


unit     x01m7a
```

```
restart
join     imode
jump     n47,x01m7a,x01m7aa
***

unit     x01m7aa
base
back     x01m6a
next     x01m7a1
at       707
write       Set the FUNCTION GENERATOR at 4000 Hz and connect
         the nonadjustable SQUARE wave to channel B.

            Connect the AUDIO OSCILLATOR to the A channel
         with a frequency of 3000 Hz, and adjust the AMPLITUDE
         to a comfortable level.

            Trigger the SCOPE from the FUNCTION GENERATOR.

            Adjust the display until both voltages appear.
         The red A*B SEPARATION knob, to the left of the CRT
         screen, adjusts the separation of the zero base lines
         of the A and B traces.

            You may superpose the traces by reducing the
         separation of the zero base lines to zero. Or, you
         may separate them by raising the A zero base line
         to y = +2 and lowering the B zero base line to
         y = -2. If you turn both the PRE AMPs to OFF while
         doing this, your adjustments will be most accurate.
***

unit     x01m7a1
next     x01m7aa
pack     n33,+++++++++++++c++abcb0000c00ae00
join     ckcw
jump     n47,x,x01m7a2
***

unit     x01m7a2
next     x01m7aa
pack     n33,+++(abcd)(cd)(de)(abcd)cbae(ghi)++(abcd)++++c(fghi)+
join     ckdw
jump     n47,x,x01m7b
***

unit     x01m7b
back     x01m7a
next     x01m7c
at       510
write    Are both traces stable?
arrow    524
answer   (n,no)
at       710
write    The SCOPE is being triggered by the FUNCTION GENERATOR.

         Which is the stable trace?  (square or sine)
```

```
no     :
at     :  710
write     If they are, then you aren't!!!
arrow:    1037
specs     bumpshift
answer    (square)<wave>
***    :

unit   :  x01m7c
back   :  x01m7b
next      x01m7d
at     :  507
write     Set the TRIGGER SOURCE so that both traces are stable.
***    :

unit      x01m7d
back      x01m7c
pack      n33,+++++(fg)++++++++++++++++
join      ckd
jump      n47,x01s7a,x
at     :  1010
write     Correct!  On the INT trigger settings,the
          traces trigger independently.
next      n47,x01m7c,x01end

 ---------------------------------------------------------------- part=1, block=1 ----------


          block 11,  x01s1a


unit   :  x01s1a
next      x01s1b
back      x01s1c
at        1007
write        Adjust the INTENSITY and FOCUS controls so that
          the spot is a sharp point of light with no halo.

             The X POSITION and Y POSITION controls are used
          to move the spot around the screen.

             If no spot appears on the screen, even at full
          INTENSITY, use the BEAM FINDER control to locate it.

             Press -NEXT- for information on use of BEAM FINDER.

             Set the SCALE illumination control at 8.0.

             When the spot is properly adjusted, press -BACK-.
***    :

unit      x01s1b
back      x01s1a
next      x01s1c
at     :  507
write             USE OF THE BEAM FINDER:
```

```

         1) Turn and hold the black BEAM FINDER knob fully CW.

         2) The spot should appear on the screen. Center it
         using the red X and Y POSITION knobs.

         3) Release the BEAM FINDER when the spot is within
         a few cm of the center, and the spot should remain.
at       3005
write    If you still can't locate the spot call your instructor.
end
***

unit     x01s1c
press    next
end
***

unit     x01s1d
back     x01m1c
next     x01s1e
at       1007
write       Before using the SCOPE for any investigation,
         the A and B preamplifiers must be balanced.  This
         is essentially an adjustment of the linearity of
         their dc amplifiers.

            Balance the A PRE AMP using the procedure you
         will see when you press -NEXT-.
***

unit     x01s1e
at       510
write              BALANCING PROCEDURE


         For the preamplifier you want to balance:

         1) Set PRE AMP to OFF.

         2) Set VOLTS FULL SCALE to 1mv, and center the trace.

         3) Set PRE AMP to BAL SET and use the BAL screw
            to center the spot. Use the beam finder if
            needed. ( BAL Screw has both fine and coarse
            adjustment. Adjust slightly past center and
            then back for finer control )

         4) Check to see that the preamplifier is balanced by
            switching the PRE AMP between OFF and BAL SET.
            If the spot moves, repeat the balancing procedure.

         5) Return VOLTS FULL SCALE to desired setting.
            Call your instructor,if you are unable to
            properly balance the PRE AMPs !
end
```

```
     block 1m,  x01s1f

unit    x01s1f
back    x01s1g
next    x01s1g
at      1210
write       Something is wrong with your setup.
        You will be given information on the dials
        before you are allowed to try again.  Press
        -NEXT- for this information.
***

unit    x01s1g
next    x01s1h
at      510
write      The number in the window of the
       A VOLTS FULL SCALE dial represents the voltage
       required for a full scale deflection of 10 cm.

          With  A VOLTS FULL SCALE set at 20 volts, the
       sensitivity (volts/cm.) would be
arrow   1043
answer  <volts,volt,cm>(2)
at      1207
write      What is the minimum number of cm needed to deflect
       the spot to the edge of full scale from (0,0) ?
arrow   1530
answer  <cm>(5)
at      2007
write     Setting A VOLTS FULL SCALE to 10 volts provides
       a deflection of 10 cm for a 10 volt signal.  However,
       since the spot is now at (0,0),  a setting of 20 V
       will allow the spot to remain on the screen when a
       10 volt signal is  applied.
wrong   10
at      1710
write    If the spot were centered at the bottom of
       the screen, full scale deflection would be 10.
       Try again remembering the spot is at (0,0)
***

unit    x01s1h
at      1110
write      When applying a constant voltage to one of
       the channels, the Y DISPLAY must be set to that
       channel, or to the A vs B position.

           The TRIGGER SOURCE and the SWEEP MODE
       should be set in the OFF position for constant
       signals.
end
```

```
***    :

unit   x01s1i
back   x01m1c
next   x01m1c
at     1210
write     You cannot deflect the spot with the A PRE AMP
       in the OFF position.


          To what position should the A PRE AMP be set
       to deflect the spot ?
arrow  1840
specs  bumpshift
answer (dc)
wrong  (ac)
at     2010
write  No!  You are applying a dc or constant voltage.

---+------------------------------------------------------------ part=1, block=n ---------


        block 1n,  x01s2al


unit   x01s2a
back   x01m2a
next   x01m2a
at     1207
write     Connect the "+" terminal of the DC SUPPLY to the
       A INPUT of the SCOPE and the "-" terminal to ground.

          The DC SUPPLY generator circuit is not internally
       grounded, that is, it is floating.  However, there
       is a common-ground terminal to the right of the +
       and - terminals to which an external ground
       connection can be made.
***    :

unit   x01s2a1
next   x01m2a
back   x01m2a
at     1206
write     You have unnecessarily changed some of the dials.
       The only dials you may have needed to change were
       the A PRE AMP and the X DISPLAY. Return all other
       dials to where they were before.
***    :

unit   x01s2b
back   x01m2a
next   x01m2a
at     1410
write     You did not set the A PRE AMP to allow
       a positive voltage to cause upward deflection.
***    :
```

```
unit    x01s2c
base
back    x01m2b
next    x01m2b1
lab     x01s1e
at      1310
write       You did not deflect the spot 5 cm properly.
        On the DC SUPPLY, verify that you have set the CURRENT
        to at least 100 mA and the VOLTAGE to provide a 5
        cm deflection.  Press -LAB- if you want to
        rebalance a PRE AMP.
***

unit    x01s2d
at      1210
write       The B channel deflects the spot in
        a manner similar to that of the A channel.

           The A channel deflects vertically and the B channel
        deflects horizontally with A vs B.

            After you return to the task statement,
        you can repeat the A channel again by pressing -BACK-.
end

------------------------------------------------------------------------------- part=2, block=a ---------


    block 2a.  x01s2e!


unit    x01s2e
back    x01m2a
next    x01m2d
at      1210
write      You seem to have trouble deflecting the spot
        horizontally. You should have turned the A PRE AMP to
        OFF or should have disconnected the connection to
        the A INPUT.  Press -NEXT- to try again.

        Press -BACK- to repeat the vertical deflection task.
***

unit    x01s2f
back    x01m2e
next    x01m2e
at      1210
write       You incorrectly set the dials.
pause
erase
at      810
write       The vertical deflection is controlled
        by the        channel with Y DISPLAY at A vs B.
arrow   918
specs   bumpshift
```

```
answer  a
at      1210
write        The horizontal deflection is controlled
        by the        channel with the Y DISPLAY at A vs B.
arrow   1317
specs   bumpshift
answer  b
at      1610
write        Then to control both the A and the B
        channels, the Y Display should be set to
arrow   1750
specs   bumpshift
answer  (a) (vs,versus,vs) (b)
at      2010
write        Both the A and the B PREAMPs should
        be set in the            position to deflect
        the spot.
arrow   2124
specs   bumpshift
answer  dc
at      2410
write        Set the A and B VOLTS FULL SCALE dials to 20 V.
***

unit    x01s2g
back    x01m2e
next    x01m2e
at      1210
write       You incorrectly set the DC SUPPLY. Make
        sure that a 3 cm deflection is obtained.
***

unit    x01s2h
back    x01m2e
next    x01m2e
at      1210
write        You did not set the A and B PRE AMPs so
        a positive voltage would cause upward deflection.
***

unit    x01s2i
back    x01m2e
next    x01m2e
at      1210
write        You incorrectly connected the DC SUPPLY to
        the SCOPE!
```

```
------------------------------------------------------------------ part=2, block=b -----------


     block 2b,  x01s3a


unit    x01s3a
base
back    x01m3a
```

```
next     x01m3a
lab      x01s3b
data     x01s3c
at       1210
write         Press the desired key for the information
         you want;

              -LAB-   Voltage peak to peak or Vp-p.
              -DATA-  Connections.
              -NEXT-  To return to the task.
***

unit     x01s3b
back     x01m3a
next     x01m3a
origin   72,352
axes     0,-101,300,100 .
scalex   2π
scaley   10
markx    π,π/4
labely   10,2.5
delta    .2
funct    10sin(v77),v77
at       2510
write    What is the peak to peak voltage of this wave?
arrow    2556
ansv     20,2
no
at       2710
write    The peak to peak voltage is the voltage between
         Vmax  and  Vmin.
hbar     372,10,-
graph    372,10,Vmax
hbar     372,-10,-
graph    372,-10,Vmin ,
vector   9π/4,0,9π/4,9.6
vector   9π/4,0,9π/4,-9.6
at       1054
write    Vp-p
write
end
***

unit     x01s3c
next     x01m3a
at       1210
write         Shown below are the three terminals
         of the AUDIO OSCILLATOR.  To apply a sine
         wave to the A INPUT of the SCOPE,
         the A INPUT must be connected to what
         terminal of the AUDIO OSCILLATOR. (A,B, or C)
circle   8,160,192
circle   8,192,192
circle   8,224,192
draw     2026;200,178;194,172;157,172;152,177;152,191
         skip;167,191;167,183;184,183;184,191
at       157,184
```

```
write    A   B   C
arrow    1740
specs    bumpshift
answer   c
at       2410
write        This is the only connection you need since
         the SCOPE and the AUDIO OSCILLATOR are internally
         grounded.
wrong    (a,b)
at       2410
write    No! Terminal B is connected to ground.
         Notice the ground strap between A and B.
no
at       2410
write    NO!!! Type the letters A, B, or C.
end
***

unit     x01s3d
next     x01s3c
at       1210
write        You incorrectly connected the AUDIO OSCILLATOR
         to the SCOPE.  Press -NEXT- for help.
***

unit     x01s3e
next     x01m3a
at       1010
write      You were not to change the dials on the SCOPE!
         Reset them in these positions:

                 A VOLTS FULL SCALE     20 V
                 SWEEP MODE             OFF
                 TRIGGER SOURCE         OFF
                 A PRE AMP              +DC
                 Y DISPLAY              A vs B
***

unit     x01s3f
next     x01m3a
at       1210
write        The output frequency of the AUDIO OSCILLATOR is
         incorrectly set.  Remember the output frequency
         is the product of the RANGE dial and the frequency
         dial.
------------------------------------------------------------------------- part=2, block=c -----------


      block 2c.  x01s3g


unit     x01s3g
base
next     x01m3a
```

```
help    x01s3b
at      1210
write       The AMPLITUDE of the AUDIO OSCILLATOR is
        incorrectly set.

        Press -NEXT- to try again.
        Press -HELP- if uncertain about Vp-p.
***

unit    x01s3h
define  switch=1
        trmnl=2
        ground=3
char    trmnl
        o000016,o000033,o000021,o000033,o000016,o000000,o000000,o000000
char    switch
        o000000,o000340,o000760,o001777,o001777,o000760,o000340,o000000
char    ground
        o000000,o100000,o120000,o124000,o124000,o120000,o100000,o000000
draw    1606;1635;2135;2106;1606
circle  8,160,217
circle  25,160,217
circle  4,184,199
circle  10,224,227
circle  6,224,227
at      256,245
plot    trmnl
at      256,235
plot    trmnl
at      256,225
plot    trmnl
at      256,215
plot    trmnl
at      256,205
plot    trmnl
at      256,185
plot    trmnl
at      240,185
plot    trmnl
at      222,185
plot    trmnl
circle  5,201,185
circle  8,115,230
circle  8,83,230
at      51,237
plot    trmnl
at      51,227
plot    trmnl
at      51,217
plot    trmnl
at      88,188
plot    switch
at      210
write      The nonadjustable outputs have fixed voltages.
           There is no way to alter this.
size    5
at      279,208
```

```
write   }
size    0
at      1039
write   Nonadjustable
           Outputs
pause
at      610
write       The adjustable OUTPUT is controlled by the
        ATTENUATOR, the OUTPUT selector, and the DC LEVEL.
        The ATTENUATOR and DC LEVEL controls are interdependent.
draw    224,125;224,181;skip;220,179;224,183;220,179
at      184,108
write    Adjustable
           OUTPUT
draw    140,121;198,179;skip;198,174;198,179;193,179
at      48,117
write   DC LEVEL
draw    222,225;265,268;skip;222,230;222,225;227,225
at      1534
write   ATTENUATOR
draw    180,271;215,236;skip;211,235;216,235;216,240
at      1515
write    OUTPUT
end
------------------------------------------------------------------ part=2, block=d -----------


        block 2d,  x01s3i


unit    x01s3i
next    x01m3c
at      1310
write       You incorrectly set the dials.  Read the
        problem carefully.  You are given which dials
        you needed to change.
***

unit    x01s3j
next    x01m3c
at      1310
write       It is necessary to again drive the A channel from
        the AUDIO OSCILLATOR.
***

unit    x01s3k
back    x01m3e
next    x01m3e
at      705
write   The Y DISPLAY FUNCTION should be set to the
        position to display the sine wave on the A INPUT.
arrow   749
specs   bumpshift
answer  a
at      1205
```

```
write      To internally trigger the SCOPE, the TRIGGER
         SOURCE should be set at
no
at       1005
write      The Y DISPLAY FUNCTION should be set to the A
         position to display the sine wave on the A channel.
arrow    1330
specs    bumpshift
answer   <ac,dc>(int,internal)
at       1810
write      The SWEEP MODE should be set to the DRIVEN -
         VARIABLE LENGTH position.

           Set the TIME at 50 ms (1/frequency), so that one
         period (T) of the sine wave appears on the screen.
no
at       1510
write      The TRIGGER SOURCE should be set to the INT
         position when you internally trigger the SCOPE!
end
***

unit     x01s3l
next     x01s3k
at       1210
write      You have incorrectly set the dials.

           Instructions on how to correct these errors
         will be given when you press +NEXT-.
***

unit     x01s3m
next     x01m3e1
at       1210
write      You don't need that wire connected to the B INPUT.
------------------------------------------------------------------ part=2, block=e --------


     block 2e.  x01s4a!


unit     x01s4a
next     x01s3h
at       505
write      To what position must the TRIGGER SOURCE be set
         to permit the SCOPE to be externally triggered ?
arrow    653
specs    bumpshift
answer   <ac,dc>(ext,external)
at       1410
write      The  only connection needed to externally
         trigger the SCOPE from the FUNCTION GENERATOR
         is a connection from the _______________ terminal of
         the SCOPE to the___________________ terminal of the
         FUNCTION GENERATOR.
```

```
no
at        1110
write        It should be set in an EXT position.
arrow     1634
specs     bumpshift
answer    <the,terminal>(trig,trigger) (in,input)
no
at        2410
write        The terminal on the SCOPE is the TRIGGER INPUT.
arrow     1726
specs     bumpshift
answer    <the,terminal>(trig,trigger) (out,output)
jump      x01s3h
no
at        2410
write        The terminal on the FUNCTION GENERATOR is
          the TRIG OUT.
```

```
-------------------------------------------------------------------- part=2, block=f -----------

      block 2f,  x01s4b1

unit      x01s4b
define    spot=1
char      spot
          o000014,o000036,o000077,o000077,o000036,o000014,o000000,o000000
join      x01s4b1
at        245,320
plot      spot
at        2510
write          To measure the voltage of this deflection
          move the NULL dial until the voltage point is at the
          zero base line.

              Press -NEXT- to see this done.
pause
mode      erase
at        245,320
plot      spot
at        2510
write          To measure the voltage of this deflection
          move the NULL dial until the voltage point is at the
          zero base line.

              Press -NEXT- to see this done.
mode      write
at        245,253
plot      spot
pause
erase
join      x01s4b1
funct     5sin(v77),v77⇐-2π,2π,.1π
at        2510
write          If you wanted to measure the zero to
```

```
                 peak voltage (V0-p), move the trace to the
                 zero level by adjusting the NULL.  Press
                 -NEXT- to see this done.
       pause
       mode      erase
       funct     5sin(v77),v77⇐-2π,2π,.1π
       at        2510
       write         If you wanted to measure the zero to
                 peak voltage (V0-p), move the trace to the
                 zero level by adjusting the NULL.  Press
                 -NEXT- to see this done.
       mode      write
       funct     5sin(v77)-5,v77⇐-2π,2π,.1π
       end
       ***

       unit      x01s4b1
       origin    1632
       axes      -120,-120,120,120
       scalex    2π
       scaley    10
       markx     .4π,.4π,2
       marky     2,2,2
       markx     .4π,.68π
       ***

       unit      x01s4c
       next      x01m4a
       back      x01m4a
       at        1210
       write         You did not follow my instructions to leave
                 the waveform displayed on the screen.  Press
                 -NEXT- to display the waveform again.
       ***

       unit      x01s6a
       next      x01m6a
       at        1610
       write         Set the Y DISPLAY to A vs B.
       ***

       unit      x01s7a
       back      x01m7c
       next      x01m7c
       at        1210
       write         You did not set the TRIGGER SOURCE
                 in the correct position!!
       end
```

```
         block 2g,  x01end!


1323  unit     x01end
```

```
1324  back     x01m7a
1325  join     imode
1326  jump     n47,x01end,x
1327  course   n2
1328  calcc    n2='ee244',
1329           nc(n21+1)⇐(nc(n21+1)$mask$o77777777770000000000)+o4603000000,
1330           nc(n21+1)⇐nc(n21+1)
1331  output   /// student has completed experiment ///
1332  join     endunit
1333  join     jmpmes
1334  jumpout  cgeindex,quest1

1335  entry    leave
1336  end      lesson
1337  ***

1338  unit     endunit
1339  course   n2
1340  jump     n2≠'ee244',leave,x
1341  calc     nc(n21+7)⇐nc(n21+7)+ahelp
1342           vc(n21+6)⇐vc(n21+6)+atime/60000
1343  ***Incl.cge s.r. & terms sample,index,imode,comment,slides.
1344  use      eex00,ck1
1345  use      ck2
1346  use      ck3
1347  use      ck4
1348  use      ck5
1349  use      ck6
      ckc              not found                  120      202        210  330  237  388  271
                                                  580
      ckcw             not found                  411      617        696
      ckcl             not found                  125      243
      ckd              not found                   98      130        138  226  157  270  197
                                                  325      352        385       583  731  658
      ckdw             not found                  417      631        702
      ckdl             not found                  101      133        141  234  207  279  229
                                                  282      285        333
      endunit    x01end             1338           23     1332
      imode            not found                   35      393        594       668       1325
      jmpmes           not found                 1333
      leave      x01end             1335         1340
      x01end     x01end             1323          735     1326
      x01m0a     x01m0a               31           36       54
      x01m1a     x01m1a               51           34       68
      x01m1b     x01m1a               66           55       81
      x01m1c     x01m1a               78           69      105        771       847       848
      x01m1c1    x01m1a               96           82
      x01m2a     x01m2a              104           99      145        864  917  865  985  876
                                                  886      914
      x01m2a1    x01m2a              117          106
      x01m2a2    x01m2a              123          121
      x01m2a3    x01m2a              128          121
      x01m2a4    x01m2a              136          126
      x01m2b     x01m2a              144          118      134        142       161       893
      x01m2b1    x01m2a              155          146      894
      x01m2c     x01m2a              160          158      181
      x01m2d     x01m2d              179          162      214        915
```

```
x01m2d1     x01m2d               195                 182
x01m2d2     x01m2d               200                 198
x01m2d3     x01m2d               205                 198
x01m2e      x01m2d               213                 203       211         248   954     924   960   925
                                                     966       967         973           974

x01m2e1     x01m2d               223                 215
x01m2e2     x01m2d               232                 227
x01m2e3     x01m2d               241                 238
x01m2f      x01m2d               247                 224       239         245           259
x01m3a      x01m3a               256                 249       289         981   974     982  1023   993
                                                    1060      1071        1080

x01m3a1     x01m3a               269                 260
x01m3a2     x01m3a               274                 272
x01m3b      x01m3a               288                 277       306
x01m3c      x01m3a               305                 290       339         342          1162        1169
x01m3c1     x01m3c1              323                 307
x01m3c2     x01m3c1              328                 326
x01m3d      x01m3c1              341                 331       358         362
x01m3d1     x01m3c1              350                 343
x01m3e      x01m3c1              360                 353       398        1175          1176
x01m3e1     x01m3c1              383                 363      1212
x01m4a      x01m4a               391                 389       394         423           430  1304  1303
x01m4a0     x01m4a               396                 394       412         418
x01m4a1     x01m4a               409                 399
x01m4a2     x01m4a               415                 413
x01m4b      x01m4a               426                 422       555         578
x01m4b0     x01m4a               421                 419
x01m4c      x01m4a               448                 431
x01m4d      x01m4d               488                 484       507
x01m4d1     x01m4d               509                 498
x01m4d2     x01m4d               513                 498
x01m4d3     x01m4d               521                 498
x01m4d4     x01m4d               529                 502       504
x01m4d5     x01m4d               534                 502       504
x01m4d6     x01m4d               539                 504
x01m4e      x01m4d               544                 490
x01m4f      x01m4d               554                 545       577         599
x01m4g      x01m4d               575                 556
x01m5a      x01m5a               592                 576       595
x01m5a0     x01m5a               597                 595       618         622
x01m5a1     x01m5a               615                 600
x01m5b      x01m5a               621                 619       633         636
x01m5b1     x01m5a               629                 623
x01m5c      x01m5a               635                 632       643
x01m5d      x01m5a               642                 637       652
x01m6a      x01m5a               651                 644       673        1311
x01m7a      x01m7a               666                 653       669         706          1324
x01m7aa     x01m7a               671                 669       694         700
x01m7a1     x01m7a               693                 674
x01m7a2     x01m7a               699                 697
x01m7b      x01m7a               705                 703       723
x01m7c      x01m7a               722                 707       729         735          1316        1317
x01m7d      x01m7a               728                 724
x01s1a      x01s1a               737                  56        70         752
x01s1b      x01s1a               751                 738
x01s1c      x01s1a               766                 739       753
x01s1d      x01s1a               770                  83
```

```
x01s1e    x01s1a         781              103      601      772        895
x01s1f    x01s1f         800              102
x01s1g    x01s1f         809               84      801      802
x01s1h    x01s1f         836              810
x01s1i    x01s1f         846              102
x01s2a    x01s2a         863              107      126
x01s2a1   x01s2a         875              131      139
x01s2b    x01s2a         884              134      142
x01s2c    x01s2a         891              158
x01s2d    x01s2a         903              184
x01s2e    x01s2e         913              203      208      211
x01s2f    x01s2e         923              230
x01s2g    x01s2e         958              230
x01s2h    x01s2e         965              239      245
x01s2i    x01s2e         972              244
x01s3a    x01s3a         979              261
x01s3b    x01s3a         992              983     1081
x01s3c    x01s3a        1022              984     1054
x01s3d    x01s3a        1053              272
x01s3e    x01s3a        1059              280
x01s3f    x01s3a        1070              283
x01s3g    x01s3g        1078              286
x01s3h    x01s3g        1088              308     1217     1242
x01s3i    x01s3i        1161              326
x01s3j    x01s3i        1168              334
x01s3k    x01s3i        1174              364     1205
x01s3l    x01s3i        1204              386
x01s3m    x01s3i        1211              389
x01s4a    x01s4a        1216              400
x01s4b    x01s4b        1248              432
x01s4b1   x01s4b        1293             1252     1274
x01s4c    x01s4b        1302              581      584
x01s6a    x01s4b        1310              659
x01s7a    x01s4b        1315              732
ahelp                   1341
atime                   1342
ground                  1091     1096
nc                      1329     1329     1330     1330     1341        1341
next                     767
n2                      1327     1328     1339     1340
n21                     1329     1329     1330     1330     1341        1341 1342 1342
n33                       97      100      119      124      129  140  132  156  137
                         196      201      206      209      225  236  228  242  233
                         270      275      278      281      284  332  324  351  329
                         384      387      410      416      579  630  582  657  616
                         695      701      730
n47                       36       99      102      121      126  134  131  142  134
                         158      198      203      208      211  235  227  238  230
                         244      272      277      280      283  334  326  353  331
                         386      389      394      412      413  591  418  584  419
                         595      618      619      632      659  703  669  732  697
                         735     1326
n70                      235      239      245      433      481  494  489  443  489
                         496      498      502      504
sin                     1002     1275     1283     1290
spot                    1249     1250     1254     1263     1271
station                  118      224
```

```
switch             1089      1094      1130
trmnl              1090      1092      1105      1107      1109 115  1111 117  1113
                   1119      1124      1126      1128
user                118       224
vc                 1342      1342
v??                1002      1002      1275      1275      1283      1283 1290 1298
Vma           1012
Vmi           1014
π                   997       999       999      1275      1275 1283 1275 1283 1283
                   1290      1290      1290      1296      1298      1298 1300 1300

                                  lesson information

       lesson name = eex01

       starting date = 09/23/72

       last edited on 08/22/74 at 15.35.17

                    by neal of course eecge

                    at site 7, station 12

       author name = J P Neal

       department = EE

       telephone number = 333-4351

       discipline = elec. eng. lab

       grade level = Freshman

       descripion of lesson = The Operation and Uses of the Oscilloscope, Analab 1120.
```

```
                         lesson eex02 at 2:27 am on tuesday, august 27, 1974
------------------------------------------------------------ part=1, block=a ----------


      block 1a,   eex02id

stop
****     For Neal, CGERL, Room 248 EEB.

One line description of this lesson --

     The Operation and Uses of the Audio Oscillator, HP 200AB.
                                                  Block      Unit
          Divisions of this Lesson:

                                                  eex02id
          Id for this file
          Experiment eex02:                       x02m0a     x02m0a
            Objectives                            x02m0a     x02m1a
            Frequency adjustments                 x02m0a     x02m2a
            Amplitude adjustment                  x02m2a2    x02m3a
            Compare w/function generator          x02m4a     x02m4a
            Floating mode                         x02m5a     x02m5a
            Superposition of waves                x02m5j     x02m6a
            Final test

          final edit 21 aug 74 neal.

*list   info
*list   symbols
*list   varian,charset,cgeindex,cgechar
****
start
finish  endunit
write   <at,1010> Loading the CGE Character Set
charset cgeindex,cgechar
erase
dataon
area    eex02
ext     0
------------------------------------------------------------ part=1, block=b ----------


      block 1b,   x02m0a


unit    x02m0a
restart
join    imode
jump    n47,x02m0a,x
base
next    x02m1a
zero    n60
zero    n51
```

```
at       704
write    THE OPERATION AND USES OF THE AUDIO OSCILLATOR, HP 200AB
at       1005
write       The purpose of this experiment is to experimentally
         study the operation of the Audio Oscillator as a
         sine-wave voltage generator, and use it in various modes.

            The specific tasks of this experiment are to examine:

         1)  Frequency adjustments.
         2)  Amplitude adjustment and measurement.
         3)  Comparisons with the Function Generator.
         4)  The floating mode of the Audio Oscillator.
         5)  Superposition of waveforms.
***

unit     x02m1a
restart
base
next     x02m1b
back     x02m0a
at       807
write       The Audio Oscillator produces a sine-wave voltage
         over a range of frequencies which nearly coincides
         with the range of audible acoustical frequencies.

            The parameters of the generated sine-wave voltage
         are its frequency and its amplitude. These parameters
         can be varied by adjustments of the dials on the front
         panel of the Audio Oscillator.

            The output frequency in Hertz is designed to be
         within 2 percent of the product of the settings of the
         large frequency dial and the RANGE dial.

            The output amplitude is adjusted by the AMPLITUDE
         dial. This dial is not calibrated in volts.

***

unit     x02m1b
back     x02m1a
next     x02m1c
at       808
write       Adjust the Audio Oscillator to generate a
         frequency of approximately 5000 Hertz.
***

unit     x02m1c
pack     n33,+++++++++++++++++++<c(kl)df>+
join     ckd
jump     n47,x02s01a,x02m2a
***

unit     x02m2a
restart
```

```
base
back      x02m1b
next      x02m2a1
help      x02s02a
at        708
write        Now that you have set the Audio Oscillator
          frequency properly, turn up the AMPLITUDE dial all
          the way and display one period of the Audio Oscillator
          output waveform on the A channel of the Scope so you
          can most accurately measure the peak-to-peak value.

             Set the Sweep Mode to the Driven Variable Length
          Position.  This is the most stable and recommended
          mode of operation for most signals.

             Internally Trigger the scope for this setup.
at        2920
write     -HELP- is available
***

unit      x02m2a1
pack      n33,000000000000c00b0000000000bc00
join      ckc
jump      n47,x02s03a,x02m2a2

------------------------------------------------------------------ part=1, block=c --------


          block 1c,  x02m2a2


unit      x02m2a2
pack      n33,+ep+d(fg)(abcd)a+++++++++++v(cd)(fl)+
join      ckd
calcc     n47,n60⇐n60+1,n60⇐0
jump      n60,x,x,x02s04a,x02s05a,x02s05b
jump      n47,x02s04a,x02m2b
***

unit      x02m2b
back      x02m2a
next      x02m2c
at        1007
write        Measure Vp-p of the sine wave.

             Hint:    Peak-to-peak expanse is easiest to observe
          when the SWEEP is turned OFF.

             What peak-to-peak voltage did you read?

               Vp-p=
arrow     1720
ansv      85.5
no
at        2110
write        Your voltage measurement is too inaccurate.
```

```
           Check your measurements!
***

unit       x02m2c
back       x02m2b
next       x02m3a
at         607
write         Good.

              Without moving the AMPLITUDE control on the
           Audio Oscillator, observe the amplitude of the
           output sine wave voltage on the Scope while you
           vary the frequency of the Audio Oscillator over
           its entire operating range.
pause      3
at         1407
write         Does the amplitude of the output vary with frequency ?
arrow      1626
answer     (y,yes,Y,Yes)
at         1707
write         Right!  The amplitude does vary somewhat.
wrong      (n,no,No)
at         1707
write         Look at it more carefully, while you vary the
           frequency from the lowest to the highest settings.
***

unit       x02m3a
restart
base
back       x02m2b
next       x02m3b
at         807
write         The Function Generator is also capable of producing
           a sinusoidal waveform of adjustable frequency and
           amplitude.

              We will now use the Scope to compare the adjustable
           SINE output of the Function Generator with the output
           of the Audio Oscillator.
***

unit       x02m3b
back       x02m3a
next       x02m3c
at         1507
write         Connect the adjustable SINE output of the Function
           Generator to the B channel of the Scope.

              The Function Generator is grounded by the links
           between the lower right terminals on its front panel,
           so only one connection from the Function Generator
           is necessary.
***

unit       x02m3c
pack       n33,+++++++++++++++bc+++++c+++b+++
join    ckc
jump    n47,x02s06a,x02m3d
***

unit    x02m3d
restart
back    x02m3b
next    x02m3e
at      807
write      Set the Function Generator to produce a sine
        wave with a frequency of 5000 Hz. and with a
        maximum amplitude.

           (If you would like to review the operation
        of the Function Generator, press -LAB-.)

           Now, set the Scope to display the A and B
        channels alternately, with both the A and B VOLTS
        at 100 volts and with internal triggering.
lab     x02s07a

------------------------------------------------------------------ part=1, block=d --------


      block 1d,  x02m3e


unit    x02m3e
pack    n33,p+p(bc)d(fg)(bc)db+g(ijk)bv+++++++++
join    ckd
jump    n47,x02s08a,x02m3f
***

unit    x02m3f
back    x02m3d
next    x02m3g
at      807
write      Use the Scope to compare the output waveshapes
        of the Function Generator and the Audio Oscillator.

           As you experiment with various controls, make any
        observations necessary to answer the following questions.
do      x02s09a
at      1407
write      Which instrument has the greater maximum output
        amplitude?
arrow   1536
answer  a
at      1607
write      RIGHT!  The Audio Oscillator is capable of
        producing the largest amplitude sine wave.
***

unit    x02m3g
back    x02m3f
next    x02m3h
```

```
at        807
write         Which instrument has the higher maximum frequency?
at        1307
write         Which instrument has the lower minimum frequency?
do        x02s09a
arrow     930
bump
answer    a
wrong     b
at        1007
write         Look at both the frequency dial and the
          MULTIPLIER(range) dial.
arrow     1430
answer    b
wrong     a
at        1507
write         Look at both the frequency dial and
          the MULTIPLIER(range) control
***

unit      x02m3h
back      x02m3g
next      x02m3i
at        707
write         With both sine waves at about the same frequency
          you may be able to notice that one of the generators
          produces a better quality sine wave.

              Which generator is it?
arrow     1135
specs     nookno,bumpshift
match     n51,a,b
at        1140
writec    n51,no,ok,no
endarrow
at        1308
write         The Audio Oscillator produces a pure sine wave
          in its internal oscillator circuit.

              The Function Generator produces its sine wave
          by means of waveshaping circuits.
at        2007
write         Thus the Function Generator 'sine wave' is not as
          pure a sine wave as that of the Audio Oscillator.
          It has noticeable imperfections.
***

unit      x02m3i
back      x02m3h
next      x02m4a
at        1007
write         In experiments which require the use of
          a sinusoidal source, it is generally desirable
          to use the Audio Oscillator and not the
          Function Generator because of the Audio Oscillator's
          purer quality output and greater range.
```

block 1e, x02m4a:

```
unit    x02m4a
join    imode
jump    n47,x02m4a,x
base
restart
back    x02m3i
next    x02m4b
at      807
write      As mentioned before, the Audio Oscillator is
        normally grounded by the ground link at its terminals.

           As you might suspect, it is also possible to operate
        the Audio Oscillator in its ungrounded or floating mode.

           Now prepare the Audio Oscillator for operation
        in its floating mode by disconnecting its left
        output terminal from ground.
***

unit    x02m4b
pack    n33,++++++++++++0++++++++++++++0++
join    ckc
jump    n47,x02s10a,x02m4c
***

unit    x02m4c
next    x02m4d
at      1007
write      With the Audio Oscillator set to operate in its
        floating mode, it can be connected in series
        with other generators or the DC SUPPLY. The net
        output voltage of the series combination would
        then be the sum of the individual output voltages.
***

unit    x02m4d
back    x02m4c
next    x02m4e
help    x02s11a
at      707
write      Let's use the Function Generator with the Audio
        Oscillator in its floating mode and add a square
        wave to a sine wave.

           Connect the adjustable SQUARE output of the Function
        Generator to one of the terminals of the Audio
        Oscillator.

           Then connect the other terminal of the Audio
        Oscillator to the A INPUT of the Scope.
```

```
                 Trigger the Scope from the Function Generator.
     at       3125
     write    Help is available.
     ***

     unit     x02m4e
     pack     n33,0000000000000000a0c0000bc00ba00
     join     ckc
     jump     n47,x,x02m4f ,
     pack     n33,0000000000000000a0c0000bc00ab00
     join     ckc1
     jump     n47,x02s11a,x02m4f
     ***

     unit     x02m4f
     back     x02m4d
     next     x02m4g
     at       1007
     write       Good! Now set the frequency of the Function
              Generator to 5000 Hz and the frequency of the
              Audio Oscillator to twice that frequency.

                 Display one period of the square wave on the Scope.
     ***

     unit     x02m4g
     pack     n33,+e++d(de)(cd)a+ag(ijk)d+(abcd)++++<c(pqr)d(klm)>+
     join     ckdw
     jump     n47,x,x02m4h ,
     pause
     jump     x02m4f
     ***

     unit     x02m4h
     back     x02m4f
     next     x02m5a
     at       1007
     write       Notice how turning up the amplitudes of the Function
              Generator and the Audio Oscillator voltages influences
              the display of the sum of the two waveforms.

                 Experiment a bit. Change the frequency of the
              Audio Oscillator and see what happens.
--------------------------------------------------------------------- part=1, block=f ----------

        block 1f,  x02m5a

     unit     x02m5a
     join     imode
     jump     n47,x02m5a,x
     base
     restart
```

```
back     x02m4h
next     x02m5b
zero     n95
at       707
write       You have seen how the Audio Oscillator and the
         Function Generator can be used to add two waveforms.

            As you should have noticed, in that case it is
         difficult to obtain  a stable display because the
         two frequencies are not synchronized.

            Let's try a different method to superpose two
         waveforms.
---------------------------------------------------------- part=1, block=g --------


      block 1g,  x02m5b


unit     x02m5b
back     x02m5a
next     x02m5c
at       707
write       You will need the SUPERPOSITION BOARD,
         ITEM 38. Please get it from the shelf below.

            The theory for the method you are about to use
         is based on Kirchhoff's Current law.

            The theory states that the current leaving a
         node is the sum of the currents entering the node.

            Let me demonstrate this with a few diagrams.
***

unit     x02m5c
back     x02m5b
next     x02m5d
at       407
write       Below is a node with three branches.

            The node is labled  A  and the branches are
         labled 1 through 3.
at       1632
write    o
at       1613
write    o
at       1651
write    o
at       2632
write    o
draw     251,260;251,105;skip;254,262;400,262;skip
         248,262;102,262
at       1532
write    A
```

```
at       1552
write    2
at       1512
write    1
at       2732
write    3
pause
mode     rewrite
at       607
write       Now let's assume a current reference direction
         for each branch, and label the diagram accordingly.
pause    1
mode     rewrite
at       1515
write    i1
draw     135,278;174,278;170,282;skip;174,278;170,274
at       1548
write    i2
draw     369,278;328,278;332,282;skip;328,278;332,274
draw     1835;2235;276,164;skip;272,160;268,164
at       2238
write    i3
pause
mode     rewrite
at       607
write       According to Kirchhoff's Current Law, the current
         leaving node A is equal to the sum of the currents
         entering node A.
pause
mode     erase
at       607
write       According to Kirchhoff's Current Law, the current
         leaving node A is equal to the sum of the currents
         entering node A.
mode     write
at       607
write       Therefore i3 is equal to the sum of i1 and i2
         or i3 = i1 + i2

pause    1
at       2241
write    = i1 + i2
pause
mode     erase
at       407
write       Below is a node with three branches.

            Therefore i3 is equal to the sum of i1 and i2
         or i3 = i1 + i2

mode     write
at       407
write       If the currents, i1 and i2, are two waveforms,
         then i3 will be the sum of the two waveforms.
------------------------------------------------------------ part=1, block=h ----------
```

block 1h, x02m5d

```
unit    x02m5d
back    x02m5c
next    x02m5e
at      507
write      Now that we have reviewed how two currents can be
        superposed, let's go to the SUPERPOSITION BOARD.
***

unit    x02m5e
back    x02m5d
erase
draw    1314;2514;2552;1352;1314
circle  12,132,284
circle  11,380,284
circle  11,132,131
draw    144,283;166,283;166,275
draw    153,243;153,210;158,205;148,195;158,185
        153,180;153,130;skip;143,130;357,130
draw    153,243;166,243;166,251
draw    357,130;357,180;352,185;362,195;352,205;357,210
        357,243
draw    369,284;347,284;347,276;skip;357,243;347,243
        347,251
draw    288,130;288,134;293,139;283,149;293,159;288,164
        288,168
circle  11,288,179
draw    288,189;288,199;skip;283,199;293,199;skip
        288,199;283,204;293,204;288,199
draw    288,204;288,228;skip;278,228;298,228;skip
        298,233;278,233;skip;288,233;288,286;293,281
        303,291;313,281;318,286;318,268
draw    277,179;259,179;244,204;skip;259,204;259,212
        288,212
draw    259,212;246,240;skip;259,240;259,246;288,246
circle  11,245,286
draw    288,286;255,286
draw    234,286;229,286;224,291;214,281;204,291;199,286
        199,268
draw    166,263;199,263;199,271
draw    347,263;318,263;318,268
at      1414
write   1            R1     3      R2          5
                 sw1                 sw2
                       2              4

                        sw4         C
                                7
           R4           sw3         Di        R5
                                    8

                                    R3

        11      SUPERPOSITION  BOARD
inhibit erase
jump    n95,x,x02m5f
***

unit    x02m5f
back    x02m5e
at      307
write      This is the board you will be using to
        to superimpose the wave forms.

           This board contains more components than
        you will need to use for this experiment
pause
mode    erase
at      307
write      This is the board you will be using to
        to superimpose the wave forms.

           This board contains more components than
        you will need to use for this experiment
mode    write
at      307
write      The  components that you will not need are
        the capacitor and the diode.  These must be shorted
        out by closing switches sw3 and sw4 for this experiment.
mode    erase
draw    259,179;244,204;skip;259,212;246,240
mode    write
draw    259,212;259,240;skip;259,179;259,205
inhibit erase
-------------------------------------------------------------- part=1, block=i -----------


     block 1i,  x02m5g


unit    x02m5g
next    x02m5h
mode    erase
at      307
write      The  components that you will not need are
        the capacitor and the diode.  These must be shorted
        out by closing switches sw3 and sw4 for this experiment.
mode    write
at      207
write      Now, make sure the board is connected to the CGE
        Interface by plugging the board's sensor cable into the
        jack in the center of the panel below the Function
        Generator. In addition to closing sw3 and sw4:

           Set sw1 so that terminals 1 and 2 are connected
        (sw1 in the up position).

           Set sw2 so that terminals 5 and 4 are connected
```

```
                (sw2 in the up position).
inhibit erase
***

unit     x02m5h
pack     n33,aadbb0dd0000c00000000000000c00
join     ckc
inhibit erase
jump     n47,x,x02m5i
next     x02m5j
***

unit     x02m5i
back     x02m5g
next     x02m5j
help     x02s13a
jump     n51,x02m5j,x
mode     erase
at       207
write       Now, make sure the board is connected to the CGE
         Interface by plugging the board's sensor cable into the
         jack in the center of the panel below the Function
         Generator. In addition to closing sw3 and sw4:

            Set sw1 so that terminals 1 and 2 are connected
          (sw1 in the up position).

            Set sw2 so that terminals 5 and 4 are connected
          (sw2 in the up position).
mode     write
at       107
write       Connect the non-adjustable SQUARE wave output
         from the Function Generator to terminal 5 and
         the non-adjustable sine wave output from the
         Function Generator to terminal 1.
            Connect the common input of the board (terminal 11)
         to Ground.
            Connect the A INPUT of the Scope to Terminal 8
         of the SUPERPOSITION BOARD to display the waveform
         of the total current.
            Trigger the Scope from the Function Generator.
at       2914
write    Press -HELP- to see a circuit diagram of setup
                                  or
         Press -NEXT- to have your connection checked.
inhibit erase

--------------------------------------------------------------------- part=1, block=j ---------


        block 1j,  x02m5j:


unit     x02m5j
next     x02m5i
help     x02s14a
```

```
data    x02s15a
erase
pack    n33,aacdd0cc+0k0k00c0rd0a00r000k00
join    ckc
jump    n47,x,x02m5k
calc    n95⇐-1
at      1007
write      You have some errors in your setup.

        Press -NEXT- to try again.

        Press -DATA- to see the correct circuit.

        Press -HELP- to see a list of your errors.
***

unit    x02m5k
back    x02m5i
next    x02m5l
at      1007
write      Set the frequency of the Function Generator to
        5000 Hertz and display two periods of the wave
        on the Scope.
***

unit    x02m5l
pack    n33,+f++(cd)(de)+abag(jk)++(abcd)+++++++
join    ckd
jump    n47,x02s16a,x02m5m
***

unit    x02m5m
back    x02m5k
next    x02m6a
at      1007
write      Experiment with the SUPERPOSITION BOARD for
        a while if you wish.

           When you press -NEXT- you will be taken to
        a short review covering the Audio Oscillator.
***

unit    x02m6a
base
restart
join    imode
jump    n47,x02m6a,x
back    x02m5m
next    x02m6b
at      607
write      You are ready for a short review covering your
        experimental examination of the Audio Oscillator.

***

unit    x02m6b
back    x02m6a
```

```
next     x02m6c
at       607
write       Set the  Audio Oscillator to:

         Operate at a frequency of about 20,000 Hertz.

         Be in the nonfloating mode.

         Generate a peak-to-peak voltage of about 40 volts.
***

unit     x02m6c
calc     n51⇐n51+1
pack     n33,+++++++++++++++++++<d(pq)c(uv)>+
join     ckdw
jump     n47,x,x02m6ca
next     x02s18a
***

unit     x02m6ca
pack     n33,++++++++++++c++a++++++++++ac++
join     ckcw
jump     n47,x,x02m6d
next     x02s18a
***

unit     x02m6d
back     x02m6b
next     x02end
at       707
write          Great!

            Experiment on your own for a few minutes if you wish.
***

unit     x02s01a
next     x02m1b
at       1007
write       The frequency setting of the Audio Oscillator
         is not quite right.

            Recall, that the frequency of the generated output
         is the product of the frequency dial setting and
         the RANGE dial setting.

            If the frequency dial is set at 40 and the RANGE
         dial is set at 200, the generated frequency should
         be ____________ Hz.
arrow    1911
ansv     8000.,1
end

----------------------------------------------------------------- part=1, block=k --------


block 1k,  x02s02a
```

```
unit      x02s02a
next      x02s02b
at        1007
write        In order to display a specific waveform on the Scope
          so the amplitude can be most accurately read:

             The Y DISPLAY FUNCTION must be set to the pertinent
          INPUT channel.

             Recall that every reading from the CRT screen has
          a possible error of 0.3 cm.  Therefore, the calibrated
          VOLTS FULL SCALE must be set as low as possible in order
          to give maximum vertical traverse to the displayed
          waveform.

             The TIME FULL SCALE of the Scope must be
          set to display the desired number of periods of
          the waveform.

             Press -BACK- if you are ready to proceed,

                          or

          press -NEXT- if you need more help on the Time setting.
***

unit      x02s02b
at        507
write        Let T represent the time duration in seconds of
          one period of the waveform.

             One period of a sine wave is shown below.
origin    1616
axes      0,-100,256,100
scaley    1
scalex    2π
labely    1,.25
markx     π,π/4
write     ‹at,1731›T/2‹at,1748›T
funct     sin(v57),v57⇐0,2π,.02π
at        2507
write        If the frequency of the sine wave is 4000 Hz,
          the period T of the wave expressed in milliseconds is
          T = 1000/frequency = ______________ ms.
arrow     2729
ansv      .25
mode      rewrite
write     ‹at,2910›Right! and T/2=.125‹at,1730›.125‹at,1747›.25‹at,1650›msec
mode      write
go
end
***

unit      x02s03a
next      x02m2a
```

```
at      1007
write      Both the Scope and the Audio Oscillator circuit
        commons are normally grounded  by links on their
        front panels.  Then, in this case, only one connection
        is required between the ungrounded output of the Audio
        Oscillator and the INPUT of the Scope.

           CHECK your connections again.
end
***

unit    x02s04a
next    x02m2a
at      707
write      Remember that the period (in seconds) of a waveform
        is the reciprocal of the frequency.  T = 1/f.

           To observe only one complete cycle of a waveform,
        the TIME FULL SCALE of the Scope must be set to
        one period.

           Also check the setting of the dials relating to
        the A channel on the Scope.

------------------------------------------------------------------------- part=1, block=1 ---------


     block 11,  x02s05a


unit    x02s05a
back    x02m2a
next    x02s05b
at      1017
write        Having problems ?


        Press -BACK- to try again, or

        press -NEXT- to see your errors.
***

unit    x02s05b
join    ckd2w
next    n47,x02m2a,x02m2b
***

unit    x02s06a
next    x02m3b
at      807
write   Hint!

            The red adjustable-output jack of the Function
        Generator is located directly below the red
        ATTENUATOR knob.
```

```
               Verify that the Audio Oscillator remains
            connected to the A channel of the Scope.
      ***

      unit     x02s07a
      at       807
      write       The frequency of the Function Generator output
               is the product of the CYCLES/SEC dial setting and
               the MULTIPLIER dial setting.

                  The black OUTPUT knob selects the shape of
               the adjustable-output waveform at the red output
               jack directly below it.

                  The red ATTENUATOR knob controls the amplitude
               of the waveform at the red output jack. As usual,
               maximum amplitude is fully clockwise.
      end
      ***

      unit     x02s08a
      next     x02m3d
      at       1007
      write       You had better check your dial sett[illegible]again.
      end
      ***

      unit     x02s09a
      at       1907
      write       To answer Audio Oscillator,     type-   a
                  To answer Function Generator, type-   b
      end
      ***

      unit     x02s10a
      next     x02m4a
      at       1007
      write       HINT!  The left red output terminal of the Audio
               Oscillator is normally connected to the black ground
               terminal by a metal ground link.
      end
      ***

      unit     x02s11a
      next     x02s12a
      at       1007
      write    The Function Generator and the Audio Oscillator
               should be connected in series, that is they should
               form a single continuous loop to the Scope.
      circle   32,152,208
      draw     1924;1936;2236;2242;2142;skip;304,169;1739;1746
               360,169;304,169;skip;2144;2744;2729;2829;skip
               2933;2633;2614;2914;2933;skip;2831;240,40;skip
               250,40;230,40;skip;235,35;246,35;skip;243,31
               238,31;skip;1916;1912;2012;skip;102,192;74,192
               skip;80,186;96,186
      draw     ;skip;92,180;85,180
```

```
at          128,203
write       SCOPE
at          1940
write        A.O.
at          2818
write.      F.G.
circle      3,328,176
circle      3,344,176
circle      3,314,176
circle      3,240,64
circle      3,224,64
inhibit erase

--------------------------------------------------------------- part=1, block=m ---------


         block 1m,   x02s12a


unit        x02s12a
next        x02m4d
mode        erase
at          1007
write       The Function Generator and the Audio Oscillator
            should be connected in series, that is they should
            form a single continuous loop to the Scope.
mode        write
at          1007
write       The best source for the external trigger of the
            Scope is the TRIG OUT of the Function Generator.
circle      3,115,84
draw        115,84:115,128:155,128:155,176
at          2703
write       TRIG OUT
end
***

unit        x02s13a
back        x02m5f
calc        n51⇐-1
mode        erase
at          107
write          Connect the non-adjustable SQUARE wave output
            from the Function Generator to terminal 5 and
            the non-adjustable sine wave output from the
            Function Generator to terminal 1.
               Connect the common input of the board (terminal 11)
            to Ground.
               Connect the A INPUT of the Scope to Terminal 8
            of the SUPERPOSITION BOARD to display the waveform
            of the total current.
               Trigger the Scope from the Function Generator.
at          2914
write       Press -HELP- to see a circuit diagram of setup
                                    or
            Press -NEXT- to have your connection checked.
```

```
entry    x02s13ae
next     x02m5j
draw     199,263;166,263;skip;318,263;347,263
mode     write
circle   32,96,448
draw     209;228;628;609;209;skip;236;256;656;636;236
at       213
write    SCOPE                         F. G.
draw     199,263;166,275;skip;318,263;347,276
circle   3,432,464
circle   3,432,441
circle   3,166,422
circle   3,143,434
circle   3,290,461
circle   3,383,424
draw     287,461;256,461;256,400;166,400;166,419;skip
         143,431;143,367;47,367;47,160;144,160
circle   8,152,160,180,0
draw     160,160;272,160;278,174
         skip;435,463;459,463;459,283;390,283;skip
         434,440;450,440;450,324;132,324;132,295
         skip;383,421;383,346;80,346;80,130;121,130
at       318
write                        T.O.          SQ

          A                               SIN
              T.I.                  GRD
at       2910
write    After you have made your connections, press -NEXT-.
end

--------------------------------------------------------------------- part=1, block=n -----------


     block in,  x02s15a


unit     x02s14a
join     ckc1w
next     x02m5j
help     x02s15a
at       2907
write    Press -HELP- to see a circuit diagram of the setup

                             or

         Press -NEXT- to have your connections checked.
***

unit     x02s15a
do       x02m5e
mode     erase
draw     259,179;244,204;skip;259,212;246,240
mode     write
draw     259,212;259,240;skip;259,179;259,205
```

```
mode     erase
goto     x02s13ae
end
***

unit     x02s16a
next     x02m5k
help     x02s17a
at       1007
write    One or more of your dial settings are wrong.

         Press -NEXT- to have your dials rechecked

                        or

         Press -HELP- for a listing of your dial errors.
***

unit     x02s17a
pack     n33,+f++(cd)(de)+abag(jk)++(abcd)+++++++
join     ckd1w
end
***

unit     x02s18a
help     x02m4a
at       810
write    You seem to have had difficulty with the review.

           Press the number you want to do:

             1.  Repeat the review quiz.

             2.  Repeat this experiment.

             3.  Review frequency and amplitude.

             4.  Review floating or grounded operation.
arrow    1045
long     1
store    n1
answer   (1,2,3,4)
jump     n1,x,x,x02m6a,x02m0a,x02m1a,x02m4a
***

unit     x02end
back     x02m6b
join     imode
jump     n47,x02end,x
course   n2
calcc    n2='ee244',
         nc(n21+1)⇐(nc(n21+1)$mask$o77777777770000000000)+o4603000000,
         nc(n21+1)⇐nc(n21+1)
erase
output   /// student has completed experiment ///
join     endunit
join     jmpmes
```

```
966  jumpout cgeindex,quest1

967  entry    leave
968  end      lesson
969  ***

970  unit     endunit
971  course   n2
972  jump     n2≠'ee244',leave,x
973  calc     nc(n21+7)⇐nc(n21+7)+ahelp
974           vc(n21+6)⇐vc(n21+6)+atime/60000
975  ***Incl.cge s.r. & TERMs sample,index,imode,comment,slides.
976  use      eex00,ck1
977  use      ck2
978  use      ck3
979  use      ck4
980  use      ck5
981  use      ck6
     ckc              not found             103      177      292      323  684  560
     ckcw             not found             664
     ckc1             not found             326
     ckc1w            not found             906
     ckd              not found              79      100      197      623
     ckdw             not found             340      658
     ckd1w            not found             936
     ckd2w            not found             765
     endunit    x02end               970     22      964
     imode            not found              32      275      356      638       956
     jmpmes           not found             965
     leave      x02end               967    972
     x02end     x02end               954    670      957
     x02m0a     x02m0a                30     33       55      952
     x02m1a     x02m0a                51     35       71      952
     x02m1b     x02m0a                70     54       85      676
     x02m1c     x02m0a                77     72
     x02m2a     x02m0a                82     80      114      735      746  766  757
     x02m2a1    x02m0a               101     86
     x02m2a2    x02m2a2              106    104
     x02m2b     x02m2a2              113    111      130      154      766
     x02m2c     x02m2a2              129    115
     x02m3a     x02m2a2              151    131      165
     x02m3b     x02m2a2              164    155      182      769
     x02m3c     x02m2a2              175    166
     x02m3d     x02m2a2              180    178      201      792
     x02m3e     x02m3e               195    183
     x02m3f     x02m3e               200    198      219
     x02m3g     x02m3e               218    202      241
     x02m3h     x02m3e               240    220      265
     x02m3i     x02m3e               264    242      279
     x02m4a     x02m4a               274    266      276      804      940       952
     x02m4b     x02m4a               290    280
     x02m4c     x02m4a               295    293      305
     x02m4d     x02m4a               304    296      330      839
     x02m4e     x02m4a               321    306
     x02m4f     x02m4a               329    324      327      343      346
     x02m4g     x02m4a               338    331
     x02m4h     x02m4a               345    341      360
```

```
x02m5a      x02m5a          355           347    357    373
x02m5b      x02m5b          372           361    385
x02m5c      x02m5b          384           374    458
x02m5d      x02m5d          457           386    465
x02m5e      x02m5d          464           459    513    915
x02m5f      x02m5d          512           510    856
x02m5g      x02m5g          539           566
x02m5h      x02m5g          558           540
x02m5i      x02m5g          565           562    599    614
x02m5j      x02m5j          598           563    567    569           875           907
x02m5k      x02m5j          613           605    627    925
x02m5l      x02m5j          621           615
x02m5m      x02m5j          626           624    640
x02m6a      x02m5j          635           628    639    647           952
x02m6b      x02m5j          646           641    669    955
x02m6c      x02m5j          655           648
x02m6ca     x02m5j          662           659
x02m6d      x02m5j          668           665
x02s01a     x02m5j          675            80
x02s02a     x02s02a         690            87
x02s02b     x02s02a         709           691
x02s03a     x02s02a         734           104
x02s04a     x02s02a         745           110    111
x02s05a     x02s05a         756           110
x02s05b     x02s05a         764           110    758
x02s06a     x02s05a         768           178
x02s07a     x02s05a         778           193
x02s08a     x02s05a         791           198
x02s09a     x02s05a         797           208    225
x02s10a     x02s05a         803           293
x02s11a     x02s05a         811           307    327
x02s12a     x02s12a         838           812
x02s13a     x02s12a         855           568
x02s13ae    x02s12a         874           921
x02s14a     x02end          905           600
x02s15a     x02end          914           601    908
x02s16a     x02end          924           624
x02s17a     x02end          934           926
x02s18a     x02end          939           660    666
ahelp                       973
atime                       974
nc                          960    960    961    961    973           973
n1                          950    952
n2                          958    959    971    972
n21                         960    960    961    961    973           973    974    974
n33                          78    102    107    176    196    325    291    339    322
                            559    603    622    657    663           935
n47                          33     80    104    109    111    276    178    293    198
                            324    327    341    357    562    634    605    659    624
                            665    766    957
n51                          37    250    252    569    656           656           857
n60                          36    109    109    109    110
n95                         362    510    606
sin                         721
vc                          974    974
v57                         721    721
π                           717    719    719    721    721
```

lesson information

lesson name = eex02

starting date = 03/29/73

last edited on 08/21/74 at 11.13.32

by neal of course eecge

at site 7, station 27

author name = J P Neal

department = EE

telephone number = 333-4351

discipline = EE

grade level = freshman

descripion of lesson = The Operation and Uses of the Audio Oscillator, HP 200AB.

```
                         lesson eex03 at 2:29 am on tuesday, august 27, 1974
------------------------------------------------------------ part=1, block=a ---------


      block 1a,  eex03id

stop
****    For Neal, CGERL, Room 248 EEB.

One line description of this lesson --

   The Operation and Uses of the Function Generator, Exact 251.

          Divisions of this Lesson:         Block    Unit

        Id for this file                    eex03id
        Experiment eex03;
          Objectives                        x03m0a   x03m0a
          Measure wave parameters           x03m1a   x03m1a
          Oper. of function generator       x03m2a   x03m2a
          Development of equi. circuit      x03m3a   x03m3a

        final edit 21 aug 74 neal.

*list   info
*list   symbols
*list   varian,charset,cgeindex,cgechar
****
start
finish  endunit
write   <at,1010> Loading the CGE Character Set
charset cgeindex,cgechar
erase
dataon
area    eex03
ext     0
------------------------------------------------------------ part=1, block=b ---------


      block 1b,  x03m0a


unit    x03m0a
restart
join    imode
jump    n47,x03m0a,x
at      408
write   THE OPERATION AND USES OF THE FUNCTION GENERATOR,
                          Exact 251.


           The learning objectives are:
```

1) To measure the period, amplitude, and average (dc) characteristics of a waveform.

2) To properly drive a two-terminal circuit with any periodic voltage having any adjustable or nonadjustable V_{max}, V_{min}, or V_{av}, and any frequency within the useful limits of the Function Generator, while triggering the Function Generator internally, externally, or manually.

3) To experimentally determine a practical equivalent circuit for the Function Generator as seen looking into its nonadjustable SQUARE wave output terminals.

```
------------------------------------------------------------------ part=1, block=c ----------
```

block 1c, x03m1a

```
unit    x03m1a
back    x03m0a
calc    n51⇐-1
zero    n60
        n61
        n62
        n63
        n64
at      1107
write     Here, you will be given an opportunity to
        review the physical properties of waveforms (i.e.,
        Vp-p, frequency, period, etc.). You should already be
        acquainted with these concepts. They will be used
        extensively in this experiment.
***

unit    x03m1b
next    x03m1c
back    x03m1a
at      210
write   From the waveform displayed below, measure
        the following quantities:
join    x03s1b
at      417
write   1) Period _________________ sec.

        2) Frequency   _____________ Hertz.

        3) Vmax        _____________ volts.

        4) Vmin        _____________ volts.

        5) Vp-p        _____________ volts.

        6) V0-p        ______________ volts.
```

```
****                doto loop avoids repeat questions
calc     n101⇐233
doto     2line,n100⇐60,64,1
calc     n101⇐n101+200
calcs    (n100-61),v102⇐.05,20,20,-20,40
calcs    (n100-61),v103⇐1.2,2.0
at       n101
writec   n(n100),⟨z,v102,v103⟩,,
2line
join     n51,x03s1a,x03s1a1,x03s1a2,x,x03s1a4,x03s1a5
***

unit     x03m1c
next     x03m1d
back     x03m1b
calc     n51⇐15                     $$ for first use of x03s1h
         n52⇐-15
         n53⇐0
at       1007
write    It is often desirable to know other characteristics
         of a wave in addition to the time - amplitude char-
         acteristics. One example would be the AVERAGE (DC)
         value of the wave.

         For now, let us concentrate our efforts on SYMMETRICAL
         waveforms; a later experiment will present a more
         mathematical approach for finding the average or dc
         value of any waveform.

-------------------------------------------------------------- part=1, block=d ---------


        block 1d,  x03m1d


unit     x03m1d
next     x03m1e
help     x03s1h
back     x03m1c
at       608
write    What is the average ( dc ) value of the symmetric
         square wave below ?        __________  volts

                        -HELP- is available
join     x03s1i
gdraw    0,15;10,15;10,-15;20,-15;20,15;30,15;30,-15;30,0
arrow    732
ansv     0
***

unit     x03m1e
help     x03s1j
next     x03m2a
back     x03m1c
calc     n51⇐20         $$ answers for second call to x03s1h
         n52⇐-10
```

```
                n53◆5
       at       608
       write    Now suppose we were to change the average or dc
                level such that the waveform is symmetrical about
                a non-zero value. Observe the effect on the wave-
                form below; what is the average (dc) value ?

                                 __________ volts

                              -HELP- is available
       join     x03s1i
       gdraw    0,20;10,20;10,-10;20,-10;20,20;30,20;30,0
       arrow    1126
       ansv     5
       ***
-------------------------------------------------------------------------- part=1, block=e -----------


         block 1e,  x03m2a


       unit     x03m2a
       restart
       at       907
       write    The Function Generator produces different signals
                over a continuous range of frequencies. The para-
                meters of these outputs are adjusted by three
                groups of dials:

                           1) OUTPUT
                           2) TIMING
                           3) TRIGGERING

                If you wish to see what any of these groups does,
                type in the number of that group. If not, just
                press -NEXT-.
       pause
       keytype  n70,1,2,3,back
       jump     n70,x03m2b,x03s2a1,x03s2a2,x03s2a3,x03m1d
       ***

       unit     x03m2b
       restart
       base
       back     x03m2a
       next     x03m2c
       help     x03s2b
       at       1105
       write       Set up the Function Generator for a nonadjustable
                RAMP Wave having a period of 2 ms.

                   Display this wave on channel A of the SCOPE, using
                the Function Generator as the trigger source.
```

```
                      -HELP- is available.

---------------------------------------------------------------------- part=1, block=f ---------


       block 1f,  x03m2c


unit    x03m2c
zero    n62
        n63
        n64
        n65
        n66
        n67
pack    n33,++(op)+(acd)(de)(abcd)a+af(ijk)++++++++++
join    ckd
calc    n55⇐n47                $$ n55=-1 if dials wrong
jump    n47,x,x03m2c1
pack    n33,++++++++++f(ijk)++++++++++
join    ckd1
calc    n62⇐n47                $$ n62=-1 if freq. wrong
pack    n33,+++++(de)+++a++++++++++++
join    ckd1
calc    n63⇐n47                $$ checks trigger
pack    n33,++++(acd)+(abcd)a++++++++++++++
join    ckd1                   $$ checks dials 5,7,8
calc    n67⇐n47
pack    n33,++(op)++++++++++++++++++
join    ckd1
calc    n64⇐n47                $$ n64⇐-1 if a-volts wrong

entry   x03m2c1
pack    n33,0000000000000000n0a000n0a000+00
join    ckc
jump    n55,x03s2c,x           $$ falls thru if dials ok
jump    n47,x03s2c,x03m2d      $$ x03s2c jumps to helps
***

unit    x03m2d
restart
base
back    x03m2b
next    x03m2d1
help    x03s2i
at      1407
write   Now set up the Function Generator for a sine wave
        with a Vp-p = 10 V and having a frequency of 1
        kHz. Trigger the Scope from the Function Generator
        and display the waveform on channel A of the Scope.

                   -HELP- is available

---------------------------------------------------------------------- part=1, block=g --------
```

```
     block 1g,  x03m2d1

unit    x03m2d1
zero    n60                        $$ pre-set for use in x03s2j
        n61
        n62
        n63
pack    n33,++(mno)++(de)+a+a<f(tuv)g(ab)>b(cdef)++++++++
join    ckd
calc    n55⇐n47
jump    n47,x,x03m2d1e
pack    n33,++(mno)++++a++++b(cdef)++++++++
join    ckd1
calc    n60⇐n47
pack    n33,+++++(de)+++a++++++++++++
join    ckd1
calc    n61⇐n47
pack    n33,++++++++++<f(tuv)g(ab)>++++++++++
*                                dial 11 on f and 12 on t,u,v
*                             or dial 11 on g and 12 on a or b

join    ckd1
calc    n62⇐n47

entry   x03m2d1e
pack    n33,000000000000000n0a0000na000+00
join    ckc
jump    n55,x03s2j,x
jump    n47,x03s2j,x03m2e
***

unit    x03m2e
base
help    x03s2q
back    x03m2d
restart
at      1406
write   Next set up the system for an adjustable square wave
        having a period of 1 ms. with a Vp-p of 10 volts. Set
        up the Function Generator to be manually triggered
        and display the waveform on channel A.

                       -HELP- is available
***

unit    x03m2g
zero    n60                          $$ pre-set for x03s2r
        n61
pack    n33,++(mnop)++(defg)+(ae)+v<f(tuv)g(ab)>d(abc)++++++++
join    ckd
calc    n55⇐n47
jump    n47,x,x03m2g1
pack    n33,++++++++++<f(tuv)g(ab)>++++++++++
join    ckd1
calc    n60⇐n47
```

```
pack     n33,++(mnop)++++(ae)++++d(abc)++++++++
join     ckd1
calc     n61⇐n47

entry    x03m2g1
pack     n33,0000000000000000n0+0000n+000+00
join     ckc
jump     n55,x03s2r,x
jump     n47,x03s2t,x03m2h
***

unit     x03m2h
restart
base
help     x03s2w
back     x03m2e
at       1206
write    Finally, set up a 20 Vp-p triangle wave at a frequency
         of 500 Hz. and a DC LEVEL of -5 volts. Display this
         waveform on channel A of the scope, which should be
         triggered from the Function Generator.

                       -HELP- is available
***

unit     x03m2i
base
zero     n60                        $$ pre-set for x03s2x
         n61
         n62
pack     n33,++(nop)++(de)c(acd)+af(ijk)c(cde)(st)+++++++
join     ckd
calc     n55⇐n47
jump     n47,x,x03m2i1
pack     n33,++++++++++f(ijk)++++++++++
join     ckd1
calc     n60⇐n47
pack     n33,+++++(de)+++a++++++++++++
join     ckd1
calc     n61⇐n47

entry    x03m2i1
pack     n33,0000000000000000n0a0000na000+00
join     ckc
jump     n55,x03s2x,x
jump     n47,x03s2x,x03m3a

------------------------------------------------------------------- part=1, block=h --------


         block 1h,  x03m3a


unit     x03m3a
base
term     equiv
```

```
restart
join     imode
jump     n47,x03m3a,x
back     x03m2h
at       1205
write    When you finish this section you should be able to:

         1) Describe and characterize the circuit model of the
            Function Generator that has been developed.

         2) Establish the applicability of this model to the
            Function Generator for any given circuit conditions.
***

unit     x03m3b
back     x03m3a
at       306
write    The Function Generator must be represented by a model
         consisting of voltage sources, resistors, and other
         circuit elements useful in circuit theory calculations.
         A logical first choice would be an IDEAL voltage source
         as illustrated below.
join     x03s3a
draw     937;1237;284,305;274,301;256,301;261,306;256,301
         261,296
at       1138
write    iL (t)
at       1806
write    An ideal voltage source, vs(t) is defined as a circuit
         element whose circuit voltage is a prescribed function
         of time and is independent of the circuit current. In
         other words, in the suggested equivalent circuit, vs(t)
         is independent of iL (t).
***

unit     x03m3c
back     x03m3b
join     x03s3a
at       1707
write    vs(t) is the open circuit voltage of the Function
         Generator. If this were the correct model, would
         you expect the amplitude or waveshape of the volt-
         age between points A and B to vary when a resistor
         is placed across the output?  (yes/no)
arrow    2410
specs    nookno,bumpshift
match    n51,yes,no
at       2417
writec   n51,no,no,ok
at       2607
write    The output voltage will not be affected when a
         resistance is placed across the outputs; it should
         be independent of the load, as specified.
***

unit     x03m3d
back     x03m3c
```

```
at      1006
write   We now have a model of the Function Generator to help
        us predict its performance in a given circuit applica-
        tion. Let us now consider a specific case and see how
        accurately this first model predicts the behavior of
        the Function Generator.

----------------------------------------------------------------- part=1, block=i ---------


        block 1i,  x03m3e


unit    x03m3e
next    x03s3b
back    x03m3d
at      405
write   According to Kirchoff's Voltage Law, V_L = V_s on
        open circuit. Since our model is an ideal voltage
        source, V_s should not change when a resistor is
        placed across the output. Let's see if this is
        the case.
join    x03s3a
draw    841;845;843;942;843;944;843;1043;skip;1243;1443
        1441;1445
at      328,330
write   V_L
at      2107
write   Set up the Function Generator to produce a non -
        adjustable square wave at a frequency of 800 hz.
        Display this waveform on channel A of the Scope
        and trigger the Scope from the Function Generator.

----------------------------------------------------------------- part=1, block=j ---------


        block 1j,  x03m3f


unit    x03m3f
back    x03m3e
help    x03s3d
next    x03s3g
at      308
write   Our model predicts that the voltage will not be
        affected when a resistor is placed across the
        output.
join    x03s3a
draw    838;296,360;285,353;296,346;285,339;296,332
        285,325;296,318;296,288
at      1708
write   Using the RESISTOR BOARD, ITEM 32, place a 500 ohm
        resistor across the output of the Function Generator
        (nodes A and B) as shown above.
```

```
                        Press -NEXT- when you have done so.
at        2308
write     **NOTE: You should still be displaying a non-
                  adjustable square wave at a frequency
                  of 800 Hz.

                               -HELP- is available
***

unit      x03m3g
back      x03m3f
at        1009
write     Our ideal voltage source model predicted that the
          voltage would not be affected when a resistor is
          placed across the output. Can the Function Generator
          be represented as an ideal voltage source?
                         _______________ (yes/no)
arrow     1422
specs     nookno,bumpshift
match     n51,yes,no
at        1431
writec    n51,no,no,ok
at        1709
write     An ideal voltage source implies that the voltage
          will not be affected when a resistor is placed
          across the output. Hence, the Function Generator
          cannot be represented by a model consisting only
          of an ideal voltage source.
***

unit      x03m3h
base
next      x03m3i
back      x03m3g
at        206
write     It would appear that the ideal voltage source model
          for the Function Generator is not adequate.
          Consider the following model.
join      x03s3e
at        2109
write     This model consists of an ideal source and an
          unknown R,L, or C element in series with it.
          If a resistor were now connected between nodes
          A and B, VAB would...(increase,decrease,not change)
at        2523
write     __________________
arrow     2524
specs     bumpshift,okextra
wrong     (increase,not change,notchange)
draw      2605;2660
at        2709
write     No. The output would decrease because RL (=500Ω)
          and the unknown R,L,or C element would form a
          voltage divider. Therefore, VAB would be only
          a fraction of VS.
answer    decrease
at        2808
```

```
write   Yes, and our earlier observation (V_AB decreased)
        would tend to support this model.
endarrow
at      3109
write   ----Hereafter, let us refer to V_AB as V_L ----
                          press -NEXT-
pause
join    x03s3k1

-------------------------------------------------------------------- part=1, block=k ---------


    block 1k,  x03m3i


unit    x03m3i
back    x03m3h
at      1007
write      We remember that the open circuit voltage of the
        Function Generator was a square wave. With an R_L of
        500 ohms connected, is the output still a square
        wave?
                   ___________( yes/no )
arrow   1420
specs   bumpshift
answer  yes
wrong   no
at      1607
write      If the output of the generator doesn't look like
        a square wave, no conclusions can be made about the
        unknown elements at this time. However, you should
        have found that the resistive load did not alter the
        waveshape and answered "yes" instead of "no".
***

unit    x03m3j
back    x03m3i
at      1207
write   The output of the generator with R_L connected is
        exactly proportional to V_s and would appear to be
        independent of time. This would lead to the con-
        clusion that the unknown element has a V/I relation
        that is independent of time. The only element that
        satisfies this condition is a _______________.
arrow   1738
specs   bumpshift,okspell
answer  (resistor,resistance)
***

unit    x03m3k
back    x03m3j
at      407
write   Can the Function Generator be represented by an ideal
        source and a resistor if the open circuit voltage is
        a square wave with a resistor across the output, and
        the following waveform results? ___________(yes/no)
```

```
at      1649
write   time
draw    1648;1609;1209;1418;2018;1827;1227;1436;2036;1845
        1645
arrow   740
specs   nookno,bumpshift
match   n51,yes,no
at      748
writec  n51,no,no,ok
at      2209
write   Since the output is not a square wave, the relation
        between V and I is not constant.
***

unit    x03m3l
back    x03m3k
calc    n51⇐2            $$pre-set for x03m3m
at      307
write      A simple equivalent circuit for an actual
        controlled - source driving a resistive load may
        be assumed as shown below, where v_s(t) is the
        voltage of an ideal voltage source and R_g is an
        internal resistance.
join    x03s3el
join    x03s3k
join    x03s3f
at      2010
write   where v_s(t) = v_g(t) + v_L(t) = R_g i_L(t) + R_L i_L(t)

        or

        v_s(t) - R_g i_L(t) = R_L i_L(t)
at      2403
write   Eq.(1)
at      2707
write   We will limit this task to determining experiment-
        ally whether an equivalent circuit of this type is
        applicable, and, if so, evaluating R_g.
```

--- part=1, block=1 ----------

block 11. x03m3m

```
unit    x03m3m
back    x03m3l
add1    n51              $$writec in x03s3l and x03s3n
join    x03s3el
join    x03s3k
join    x03s3f
at      2111
write   In our setup only R_L and V_L are known
        Noting the given reference direction,
        write an equation for I_L.

```

```
                                I_L =_1_____________________
arrow     2524
specs     bumpshift,nookno
put       ÷=/
          l=I
          s=S
          g=g
storea    n60,30
ok
search    'vs',2,n60,30,1,n61
jump      n61,x,x03s31
search    'rg',2,n60,30,1,n61
jump      n61,x,x03s31
search    'vl/rl',5,n60,30,1,n61
jump      n61,x03s3n,x03s3m
***

unit      x03m3n
base
back      x03m3m
calc      n58⇐1
          n51⇐-1              $$used in x03m3p
at        508
write     In order to experimentally measure a current, I_L,
          with the scope, we measure the voltage, V_L, produced
          across a known resistance, R_L, by that current and
          calculate

                                V_L
                        I_L  =  -------
                                R_L


          Observe I_L with R_L = 500 ohms. Is the waveshape of
          I_L identical to the waveform you observed for V_S ?
                       ____________ (yes/no)
at        2308
write     Is the point at which I_L crosses zero and is positive
          going at the same point on the display as it was for
          V_S ?

specs     bumpshift______________ (yes/no)
arrow     1616
answer    yes
wrong     no
at        1808
write     Once again the waveform is a square wave
draw      1808;1848
specs     bumpshift
arrow     2616
answer    yes
***

unit      x03m3o
base
back      x03m3n
next      x03m3p
erase
```

```
catchup
at      505
write   Eq(1)    v_s(t) - R_g i_L(t) = R_L i_L(t)
at      1007
write   Excellent, you have now shown that Eq. (1) for the
        proposed circuit is not violated for the value
        R_L = 500 ohms, in that

             v_s(t) = 500 i_L(t) + R_g i_L(t) = (500 + R_g) i_L(t)

        where R_g may be a positive real number.
at      1405
write   Eq(2)
at      2207
write   The above equation could not apply with R_g being a
        positive real number if the waveshapes of v_s(t) and
        i_L(t) differed, particularly, if i_L(t) ≠ 0 when
        v_s(t) = 0.
------------------------------------------------------------ part=1, block=m ----------


    block 1m,  x03m3p


unit    x03m3p
inhibit erase
lab     x03s2e2
back    x03m3o
help    x03s3o
data    x03s3q
next    x03m3p2
at      207
write       You have not shown that Eq(1) applies for all
        values of R_L with a specific value of R_g. To do so
        tabulate V_L p-p and I_L p-p for the specified values
        of R_L.
            When you have satisfactorily tabulated values
        for five different resistive loads, PLATO will plot
        V_L p-p versus I_L p-p.

                REMEMBER: I_L = V_L / R_L
size    2
at      1213
write   Data point no.
calc    n57⇐n58-5
at      1240
showt   n58,3
size    0
at      1412
write   Choose R_L =_____________ (ohms)

        Enter V_L  =____________ (Volts) (measured)

        Enter I_L  = ____________ (Amps) (calculated)
at      3222
```

```
write   -HELP- is available
at      1426
writec  n51,500,1000,250,100,50        $$resistor
calcs   n51,v130⇐500,1000,250,100,50
calcs   n51,v52⇐17.6,24.5,10.4,4.65,2.55    $$voltage
arrow   1623
store   v131
ansv    v52,10%
no
at      2207
write   Your readings for V_L must be as accurate as possible.
        Be sure you are displaying the largest possible
        waveform on the Scope. Press -LAB- for an explanation.
endarrow
calc    v132⇐(v131/v130)
join    x03s3p
pause
join    key=data,x03s3q,x

entry   x03m3p1
next    x03m3p2
at      1824
erase   10
catchup
at      1822
write   ____________
inhibit erase
data    x03s3q
arrow   1822
store   v56
ansv    v132
no
draw    2803;2862
at      2913
write   Thought I wasn't looking, didn't you? Let's
        try that division again. I_L (=V_L/R_L) =?
endarrow
***

unit    x03m3p2
erase
join    n58,x,x,x03s3*,x03s3r1
add1    n58
        n51
at      1521
write   Press -NEXT-
next    n57,x03m3p,x03m3q

---------------------------------------------------------------------- part=1, block=n ---------


        block 1n,  x03m3q


unit    x03m3q
base
```

```
next    x03m3r
back    x03m3n
at      310
write   For any range of IL where the graph is a straight
        line, the negative of the value of the slope can
        be used as the value of Rg and for that range the
        assumed equivalent circuit is applicable.
origin  100,100
axes    300,240
scalex  .08
scaley  30
labelx  .02,.01
labely  10,2
size    2
graph   -.02,20,VL
locate  .02,-7
write   IL  (amps)
size    0
gdraw   v142,v143;v140,v141;v144,v145;v146,v147;v148,v149
doto    1line,n100⇐140,148,2
locate  v(n100),v(n100+1)
writec  (n100-142)/2,500Ω,1000Ω,250Ω,100Ω,50Ω
1line
locate  .045,25
write   slope = -Rg
***

unit    x03m3r
next    x03end
back    x03m3q
at      409
write   Thus you have experimentally shown that this
        circuit is an acceptable equivalent circuit
        model for the function generator for a range
        of 0 < RL < ( ≈ 1000) ohms.
join    x03s3e1
at      1624
write   Rg
at      2109
write   where Rg is the assumed internal resistance of
        the function generator and Vs a voltage source.
        Beyond this range, however, the model is not
        applicable and other circuit elements must be
        included to account for variations in the slope
        of VL/IL.
```

```
----------------------------------------------------------------- part=2, block=a ----------
```

```
block 2a,  x03s1a

unit    x03s1a
arrow   431
store   v52
ansv    .05
```

```
calc    n51⇐0
        n60⇐-1
no
jump    x03s1c

entry   x03s1a1
arrow   631
ansv    20
calc    n51⇐1
        n61⇐-1
no
jump    x03s1d

entry   x03s1a2
arrow   831
store   n54
ansv    20
calc    n51⇐2
        n62⇐-1
no
jump    x03s1e

entry   x03s1a3
arrow   1031
ansv    -20
calc    n51⇐3
        n63⇐-1

entry   x03s1a4
arrow   1231
ansv    40
calc    n51⇐4
        n64⇐-1
no
jump    x03s1f

entry   x03s1a5
arrow   1431
ansv    20
no
jump    x03s1g
***

unit    x03s1b
origin  75,130
axes    0,-100,300,100
scalex  100
scaley  20
labelx  25,5
labely  10,5
gdraw   0,0;12.5,20;37.5,-20;62.5,20;87.5,-20;100,0
graph   106,-3,msecs
graph   -5,23,volts
frame   -40,-130,375,140
***

unit    x03s1c
```

```
next     x03m1b
back     x03m1b
at       505
write    No, the period of this waveform is not <s,v52> secs.
         Observe the waveform below and, remembering that the
         period is the time required for the waveform to begin
         repeating itself, determine the period.

         Note that your answer should be in units of seconds.
         (1 msec = .001 sec.)
join     x03s1b
***

unit     x03s1d
next     x03m1b
at       1005
write    No, frequency (f) is the reciprocal of the period (T).
         You have determined that the period of this waveform
         is .05 secs. Thus, since f = 1/T and T = .05 secs.:

                     f =   1      = ?? hz
                          ___
                          .05

                   Press -NEXT- to enter your answer
***

unit     x03s1e
next     x03m1b
at       806
write    You incorrectly specified Vmax as being <z,n54> volts.
         Observe how Vmax is noted on the waveform below, then
         press -NEXT- to enter the correct answer.
join     x03s1b
graph    28,10,Vmax

entry    x03s1e1
gdraw    22,20;40,20
gdraw    31,0;31,7
gdraw    31,15;31,20
***

unit     x03s1f
next     x03m1b
at       806
write    The peak-to-peak value is Vmax - Vmin. Observe this
         on the waveform below, then press -NEXT- to enter
         the correct answer.
join     x03s1b
join     x03s1e1
gdraw    31,0;31,-20
gdraw    22,-20;40,-20
graph    28,10,V(p-p)
***
```

```
unit     x03s1g
next     x03m1b
at       907
```

```
write   For this waveform V(0-p) is Vmax. Observe this on
        the figure below, then press -NEXT- to enter the
        correct answer.
join    x03s1b
join    x03s1e1
graph   28,10,V(0-p)

---------------------------------------------------------------------------------------- part=2, block=b ---------

        block 2b,  x03s1h

unit    x03s1h
join    x03s1i
gdraw   0,15;10,15;10,-15;20,-15;20,15;30,15;30,-15;30,0

entry   x03s1h1
at      214
write     Since this is a symmetrical waveform,
        the average value is the line about which
        the waveform is symmetrical.
                  -OR-
         ...taking a different approach...

           V(max)+V(min)   = AVERAGE VALUE
                 2
        Enter Vmax = ___________ volts

        Enter Vmin = ___________ volts

        The average value is then= __________ volts
arrow   1028
ansv    n51
arrow   1228
ansv    n52
arrow   1442
ansv    n53
no
at      1536
write    (⟨z,n51⟩) + (⟨z,n52⟩) = ???
               2
end
***

unit    x03s1i
origin  75,150
axes    0,-100,300,100
scalex  35
scaley  20
labely  10,5
graph   -2,22,Volts
graph   38,0,Time
***

unit    x03s1j
```

```
join      x03s1i
gdraw     0,20;10,20;10,-10;20,-10;20,20;30,20;30,0
join      x03s1h1
end
***

unit      x03s2a1
next      x03m2a
output    //output help reviewed//
at        708
write     The adjustable output of the Function Generator
          is affected by:

          1)  The Attenuator- The red dial of the OUTPUT
            group. This dial varies the voltage of the output
            waveform.

          2) Output Selector- This is the dial behind the
            attenuator. It is used to select the periodic
            signal to be controlled.

          3) ± DC Level - This dial changes the Vav
            of the adjustable output.

          4) Terminals- The only terminal affected by the
            above dials is the one directly below the
            attenuator. The terminals to the right of the
            attenuator have a constant magnitude and DC level.
end
***

unit      x03s2a2
next      x03m2a
output    //timing help reviewed//
at        1008
write       The time it takes a periodic signal to complete
          one cycle is known as the period of the waveform.
          The number of these periods that occur in one second
          is known as the frequency of the signal. The Timing
          section of the Function Generator allows the
          variation of the signal's frequency. The output
          frequency is the product of the MULTIPLIER and the
          CYCLES/SEC dials.
end

------------------------------------------------------------------ part=2, block=c -----------


        block 2c,  x03s2a3


unit      x03s2a3
output    //trigger reviewed//
next      x03m2a
at        809
write       To trigger means to initiate or start a cycle.
```

```
            This Function Generator has two ways of being
            triggered. The INT setting causes the generator
            to be on continuously. The EXT setting allows
            the Function Generator to be triggered by an
            external voltage or event. This station is not
            equipped to externally trigger the Function
            Generator ( other than manual triggering); thus
            you should use the INT setting unless you are
            instructed to do otherwise.

             The TRIG OUT terminal is used to trigger
            other instruments synchronously with the
            Function Generator.
     end
     ***

     unit   x03s2b
     back   x03m2b
     at     1107
     write  Remember that F= 1/T where:

                          F= frequency in Hertz

                          T= period in seconds

            Also, use the output terminal to the right of the
            attenuator.
     end
     ***

     unit   x03s2c
     pack   n33,0000000000000000n0+000n0+000+00
     join   ckc1
     calc   n65⇐n47
     jump   n67,x03s2e,x
     jump   n65,x03s2h,x
     jump   n62,x03s2d,x
     jump   n63,x03s2g,x
     jump   n64,x03s2e1,x03s2b
     ***

     unit   x03s2d
     next   x03m2c
     help   x03s2f
     back   x03m2b
     at     1105
     write     No, you seem to be having a problem with the timing
            aspect.  You were asked to set it for a period of 2 ms.

               Press -NEXT- if you understand your error and
            have corrected it.

               Press -HELP- if you would like some assistance.

               Press -BACK- to reread the problem statement.
     ***
```

```
unit    x03s2e
next    x03m2c
back    x03m2b
at      705
write      Unless you properly set the SWEEP MODE and A
        PRE AMP dials, you cannot display this waveform
        on the SCOPE. You should have mastered the use
        of these dials in the first experiment.

           If you need assistance, it would be best for
        you to review Experiment 1 (Operation and Use
        of the Oscilloscope ) before continuing this
        experiment.

                       -OTHERWISE-

           Press -NEXT- if you understand your error and
        have corrected it.

           Press -BACK- to reread the problem statement.

------------------------------------------------------------ part=2, block=d ------


     block 2d,  x03s2e1


unit    x03s2e1
back    x03m2b
next    x03m2c
help    x03s2e3
at      805
write      The waveform which you are displaying is not acceptable.

           Reset the A VOLTS dial so that the waveform is as
        large as possible without exceeding the boundaries
        of the Oscilloscope screen.

           Press -NEXT- when you have correctly set the
        A VOLTS dial.

           Press -BACK- if you would like to reread the
        problem statement.

           Press -HELP- for further assistance.
***

unit    x03s2e2
erase                        $$ x03m3p has inhibit erase
catchup
at      1008
goto    x03s2e3              $$ x03m3p avoids first paragraph

entry   x03s2e3
at      605
write      At this point of the experiment the size of the
```

```
          waveform is somewhat of a triviality. However,
          the final task of this experiment requires that
          you be able to accurately read the peak-to-peak
          voltage of the displayed waveform. As you increase
          the size of the displayed waveform, your accuracy
          improves. The reason for this is as follows:
at        1405

entry     x03s2e4
write        The normally specified tolerance is ≈ ± 3 %
          of the FULL SCALE voltage setting. Thus if you are
          displaying a 10 volt peak-to-peak signal on a
          FULL SCALE setting of 10 volts, you are reading
          10 volts ±  3 %, or 10 volts ±  0.3 volts.

             Now, suppose you were to decrease the size of
          the waveform by changing A VOLTS to 100 VOLTS FULL
          SCALE. Once again the tolerance is ±  3 % or
          ± 3 volts. Thus, attempting to read a 10 volt peak-
          to-peak signal on a 100 volt FULL SCALE would
          produce an answer of 10 volts ±  3  volts, an
          unacceptable reading.
end
***

unit      x03s2f
next      x03m2c
help      x03s2a2
back      x03m2b
base
at        605
write        You were asked to set the timing dials so as to
          obtain a period T of 2 ms.

             1 ms (millisecond) = .001 second = 10^-3 second.

             Therefore, T (= 2 ms) = 2×10^-3 sec.

             Frequency f is the reciprocal of the period, i.e.,
          f = 1/T

          Thus the frequency when T = 2 ms. is

                             1
                        f= _____  = 500 Hz
                           2×10^-3
at        2205
write        Press -HELP- if you would like further assistance.

             Press -NEXT- when you have set the timing dials to
          500 Hz.

             Press -BACK- to reread the problem statement.
```

block 2e, x03s2g

```
unit      x03s2g
next      x03s2g1
at        205
write        No, the system is not triggered as requested. Let's
          try a different approach.

             Beginning with the SCOPE.

             Suppose you wish to trigger the SCOPE from another
          source, such as the Function Generator, where would
          you position the SCOPE's TRIGGER SOURCE dial?

                         ______________ (ext/int)

             Now, in order to obtain that external triggering signal
          from the Function Generator which output of the
          Function Generator would you connect to the SCOPE's
          TRIGGER INPUT ?

                         _______________(Trig out/ Ext)
arrow     1118
specs     bumpshift
answer    (ext,external)
wrong     (int,internal)
draw      2060;2005;2505;2560;2060
at        2107
write     No...
               the INT setting triggers the SCOPE internally
          internally. You want to trigger the SCOPE externally.
arrow     1618
specs     bumpshift,okextra
answer    (trig out,trigout)
draw      2060;2005;2505;2560;2060
at        2107
write     Great... Once you have made the connection and/or
          dial setting adjustments as specified above you will
          have the SCOPE properly triggered. Press -NEXT- when
          you have done so.
wrong     (ext,external)
draw      2060;2005;2505;2560;2060
at        2108
write     No...
            The EXT TRIGGER is for externally triggering
            the FUNCTION GENERATOR. You want to externally
            trigger the SCOPE from the FUNCTION GENERATOR.
***

unit      x03s2g1
back      x03m2b
next      x03m2c
help      x03s2a3
at        508
write        Now that you know how to properly trigger the
          SCOPE, let's turn our attention to the Function
```

```
                Generator...

                You have already noted that a connection should
                be made between the SCOPE's TRIGGER INPUT and
                the Function Generator's TRIG OUT.  As noted,
                this connection allowed the Scope to be triggered
                externally. Thus far we have not stabilized the
                FUNCTION GENERATOR.
        at      1808
        write   Press  -HELP-  for a description of how to trigger
                               the Function Generator.

                Press  -NEXT-  if you know how to properly trigger
                               the Function Generator and have set
                               the dials accordingly.

                Press  -BACK-  to reread the problem statement.

---------------------------------------------------------------------- part=2, block=f --------


            block 2f,  x03s2h


        unit    x0[illegible]2h
        zero    n59                     $$ avoids first jump in x03m2d1
        next    x03m2c1
        back    x03m2b
        help    x03s2h1
        at      805
        write      You are not displaying a nonadjustable RAMP
                wave as requested.

                   Press -NEXT- if you understand your error and
                have corrected it.

                   Press -HELP- for assistance.

                   Press -BACK- to reread the problem statement.
        ***

        unit    x03s2h1
        base
        next    x03m2c1
        lab     x03s2a1
        at      605
        write      The nonadjustable RAMP wave output is
                located to the right of the OUTPUT dial.

                   Before changing your set-up, vary the
                setting of the ATTENUATOR. You should find
                that doing so changes the peak-to-peak value
                of the displayed waveform.

                   Now connect the nonadjustable RAMP wave
                output terminal to the SCOPE's a INPUT. You
```

```
             should now find that varying the ATTENUATOR
             setting does not change the  peak-to-peak
             value of the waveform.

                Press -NEXT- when you have connected the
             nonadjustable RAMP output to the SCOPE's A INPUT.

                Press -LAB- for a further discussion of the
             Function Generator's features output features.
     ***   :

     unit  :  x03s2i
     back  :  x03m2d
     at    :  1010
     write      Make sure that the OUTPUT selector is
             in the SINE wave position. Also be sure the
             adjustable OUTPUT terminal is connected to
             the SCOPE.
     end
     ***   :

     unit  :  x03s2j
     pack     n33,000000000000000n0+0000n+000+00
     join     ckc1
     calc     n63⇐n47
     jump     n60,x03s2k,x
     jump     n61,x03s2m,x
     jump     n62,x03s21,x
     jump     n63,x03s2k,x03s2m
     ***   :

     unit     x03s2k
     next     x03m2d1
     help     x03s2n
     back     x03m2d
     at       1009
     write      You are not properly displaying an adjustable
             SINE wave with a peak-to-peak voltage of 10 volts.


                Press -NEXT- if you understand your error and
             have corrected it.

                Press -HELP- for assistance.

                Press -BACK- to reread the problem statement.
     ***   :

     unit  |  x03s21
     next     x03m2d1
     help     x03s2p
     back     x03m2d
     at    :  705
     write      Caught you day-dreaming a little, right?
             Let's set that timing dial at 1000 Hz.


```

```
           Press -NEXT- when you have done so.

           Press -HELP- if you need assistance.

           Press -BACK- to reread the problem statement.
 ------------------------------------------------------------- part=2, block=g --------


     block 2g,   x03s2m:

unit    x03s2m
next    x03m2e
back    x03m2d
at      1005
write      You should still be triggering the SCOPE from the
        Function Generator just as you did in the previous
        exercise.

           Press -NEXT- when you have triggered the SCOPE
        from the Function Generator.

           Press -BACK- to reread the problem statement.
***

unit    x03s2n
base
next    x03s2n1
lab     x03s2a1
at      811
write      The adjustable output terminal is located
        directly below the ATTENUATOR dial. Find this
        terminal now and connect it to A INPUT on the SCOPE!

           Press -NEXT- when you have done so.

           Press -LAB- for a further discussion of the
        Function Generator's features.
***

unit    x03s2n1
pack    n33,000000000000+00n0+0000n+000+00
join    ckc
jump    n47,x,x03s2o
pack    n33,000000000000+00n0+0000n+000+00
join    ckc1w
pause
jump    x03s2n
***

unit    x03s2o
next    x03s2o1
back    x03m2d
at      1005
write      Good, now set the OUTPUT selector to the SINE
```

```
                wave position. Adjust the ATTENUATOR setting until
                the peak-to-peak voltage is 10 volts. Of course the
                SCOPE's dials should be set so that you can properly
                display this waveform on channel A.

                   Press -NEXT- when you have set these dials correctly.

                   Press -BACK- to reread the problem statement.
        ***

        unit    x03s2o1
        pack    n33,++(mno)++++a++++b(cdef)++++++++
        join    ckd
        jump    n47,x,x03m2d1
        pack    n33,++(mno)++++a++++b(cdef)++++++++
        join    ckd1w
        pause
        jump    x03s2o
        ***

        unit    x03s2p
        next    x03m2d1
        base
        at      1108
        write      The frequency of the waveform to be displayed is
                the product of the settings of the CYCLES/SEC dial
                and the MULTIPLIER dial.

                   Since you want a frequency of 1000 Hz, you should
                set the MULTIPLIER dial on 1000 and the CYCLES/SEC
                dial on ______________

        arrow   1716
        specs   bumpshift
        answer  (1,one)
        at      2008
        write                  or.....

                   You could set the MULTIPLIER dial on 100 and the
                CYCLES/SEC dial on _______________
        arrow   2327
        specs   bumpshift
        answer  (10,ten)
        at      2709
        write      Press -NEXT- when you have properly set the
                CYCLES/SEC and MULTIPLIER dials at 1000 Hz.

--------------------------------------------------------------- part=2, block=h ---------


            block 2h,  x03s2q


        unit    x03s2q
        help    x03s2v
        back    x03m2e
```

```
at      1005
write      Don't forget to put the Function Generator's
        TRIGGER dial to the MANUAL position.

           Also, f=1/T (The frequency of the Function Generator
        is the product of the MULTIPLIER and the CYCLES/SEC dials.
at      2005
write      If you would like more information on the MANUAL
        TRIGGER, press -HELP-.  Otherwise, press -NEXT- to
        continue.
end
***

unit    x03s2r
jump    n60,x03s2s,x
jump    n61,x03s2t,x03s2u
***

unit    x03s2s
next    x03m2g
at      905
write      As in the last exercise, you should have a frequency
        of 1000 Hz. Set the frequency dials at 1000 Hertz.

           Then...

        Press -NEXT-

        Press -BACK- to reread the problem statement
***

unit    x03s2t
next    x03m2g
back    x03m2e
at      905
write      Once again you are displaying an adjustable wave-
        form, this time a 10 Vp-p square wave. Carefully,
        adjust the ATTENUATOR and check the SCOPE's dial
        settings (such as A VOLTs, Y DISPLAY, etc.).

           Press -NEXT- when you are properly displaying the
        waveform.

           Press -BACK- to reread the problem statement.
***

unit    x03s2u
next    x03m2g
help    x03s2v
back    x03m2e
at      811
write      You appear to be having trouble with the
        manual trigger. Before we go further, you
        should be aware that PLATO does not sense when
        the MANUAL button is being pressed; thus, it
        is not necessary that you be pressing the
        MANUAL button when the dial check is in
```

```
         progress.  You only need to have the system
         set up to be manually triggered, press the
         MANUAL button once or twice to assure your-
         self that you have the proper set-up, then:

            Press -NEXT- for PLATO to check.

            Press -HELP- for further assistance.

            Press -BACK- to reread the problem statement.
***

unit     x03s2v
at       605
write       When the Function Generator's TRIGGER selection
         dial is set to the EXT position, the Function
         Generator may be triggered by an external voltage
         or event.  Pressing the MANUAL button may be
         considered an external event.

            You may trigger the SCOPE either internally or
         from the Function Generator.
end
------------------------------------------------------------------- part=2, block=i ---------


      block 2i,  x03s2w


unit     x03s2w
at       1105
write       The DC LEVEL control is below the ATTENUATOR.

            Carefully set this dial. Also, since this dial
         interacts with the ATTENUATOR dial, you may find it
         necessary to re-adjust the ATTENUATOR setting.

             (Since you are putting a dc component into the
          waveform, to what position should the  A PRE AMP be set ?)
end
***

unit     x03s2x
pack     n33,0000000000000000+0a0000+a000+00
join     ckc1
calc     n62⇐n47
jump     n60,x03s2y,x
jump     n61,x03s2z,x
jump     n62,x03s2z,x03s2z1
***

unit     x03s2y
next     x03m2i
back     x03m2h
at       905
```

```
write        If you've gotten this far, the timing dials should
        be causing you problems now. However, the Function
        Generator's CYCLES/SEC and MULTIPLIER dials, which
        should be set at a frequency of 500 Hz, are not set
        properly.

            Press -NEXT- when you have set these dials properly.

            Press -BACK- to reread the problem statement.
***

unit    x03s2z
next    x03m2i
back    x03m2h
at      805
write      You are not triggering the SCOPE from the Function
        Generator.

            Press -NEXT- when you have made the necessary dial
        and/or connection corrections.


            Press -BACK- to reread the problem statement.
***

unit    x03s2z1
next    x03m2i
help    x03s2z2
back    x03m2h
at      905
write      You are not displaying a triangle wave with a peak-to-
        voltage of 20 volts and a dc level of -5 volts.

            Press -NEXT- if the understand your error and
        have corrected it.

            Press -HELP- for assistance with the DC LEVEL.

            Press -BACK- to reread the problem statement.
***

unit    x03s2z2
next    x03m2i
at      505
write      Before attempting to set the DC LEVEL at -5 Volts,
        you must set the 0 Volts level on the SCOPE. To do so,
        turn the A PRE AMP to OFF, and position the trace on
        the center horizontally by means of the Y POSITION knob.


pause
write      Now that you have positioned the zero voltage level
        on the SCOPE, do not move the Y POSITION knob.  Doing
        so will dislocate the zero voltage level on the screen.

            Return the A PRE AMP from OFF to its previous setting.
```

```
               Adjust the Function Generator's DC LEVEL until the
          wave is centered about -5 V. Then readjust the
          ATTENUATOR and the DC LEVEL as necessary to obtain the
          20 Vp-p waveform with a dc level of -5 volts.'

------------------------------------------------------------ part=2, block=j ----------


     block 2j,  x03s3a:


unit      x03s3a
draw      837;824;1024;1026;1226;1222;1022;1024;skip;1224
          1424;1437
at        288,282
write     o B
at        288,376
write     o A
at        1128
write     +
          vs(t)
***

unit      x03s3b
pack      n33,++(op)++(de)+a+af(pqr)++++++++++
join      ckd
jump      n47,x,x03s3c
join      ckd1w
pause
jump      x03m3e
***

unit      x03s3c
pack      n33,000000000000+00n0an0000a000+00
join      ckc
jump      n47,x,x03m3f
join      ckc1w
pause
jump      x03m3e
***

unit      x03s3d
at        1207
write          Connect the (+) output terminal of the Function
          Generator to terminal 7 on the RESISTOR BOARD. Also,
          connect terminal 7 to (+) A-input of the Scope.

               Now connect the (-) output terminal of the
          Function Generator to terminal 8 on the resistor
          board. Terminal 8 should also be connected to the
          A INPUT of the Scope.
end
***

unit      x03s3g
pack      n33,++(no)++(de)+a+af(pqr)++++++++++
join    ckd
jump    n47,x,x03s3j
pack    n33,++(no)+++++++++++++++++++
join    ckd1
jump    n47,x03s3h,x03s3i
***

unit    x03s3h
help    x03s2e3
next    x03s3g
back    x03m3f
at      905
write      The waveform you are displaying is too small. You
        cannot measure it very accurately.

           Press -NEXT- when you have reset A VOLTS so that the
        waveform is as large as possible without exceeding
        the boundaries of the screen.

           Press -HELP- for a further explanation.

           Press -BACK- to reread the problem statement.
***

unit    x03s3i
next    x03s3g
pack    n33,++(no)++(de)+a+af(pqr)++++++++++
join    ckd1w
***

unit    x03s3j
pack    n33,000000ab0000a00b0cb0000c000+00
join    ckc
jump    n47,x,x03m3g
pack    n33,000000ab0000b00a0ca0000c000+00
join    ckc1
jump    n47,x,x03m3g
join    ckc1w
pause
jump    x03m3f
***

unit    x03s3l
next    x03m3m
at      1315
write   v_s(t) and R_g are unknowns. Write your
        equation in terms of known parameters
        only.

           press -NEXT- to try again
at      2111
writec  n51,,,ASK YOUR INSTRUCTOR FOR ASSISTANCE.......
***

unit    x03s3m
next    x03m3n
at      1416
```

```
write   Your equation will work!!

              press -NEXT-
***

unit    x03s3n
next    x03m3m
at      1615
write   No, your equation will not work

          press -NEXT- to try again.
at      2111
writec  n51,,,ASK YOUR INSTRUCTOR FOR ASSISTANCE......
```

```
------------------------------------------------------------------------ part=2, block=k ----------
```

block 2k, x03s3e

```
unit    x03s3e
at      1524
write   Unknown
        R,L,or C
        element
at      304,360
write   o  A
at      304,218
write   o  B

entry   x03s3e1
at      304,360
write   o
at      304,218
write   o
draw    939;921;1121;1120;1220;1222;1122;1121;skip;1221
        1421;1420;1620;1622;1422;1421;skip;1621;1821;1839
at      192,336
write   +
at      184,318
write   vs(t)
***

unit    x03s3f
draw    940;1140;320,328;312,320;320,312;312,304;320,296
        312,288;320,280;312,272;320,264;312,256;1840
at      1342
write   RL
draw    1235;1535;1733;1730;238,246;232,240;238,234
at      1436
write   IL
***

unit    x03s3k
at      1416
write   -
```

```
                Vg
                +
at              1624
write           Rg

entry           x03s3k1
at              306,360
erase           7
at              308,218
erase           7
draw            945;950;skip;947;1046;947;1048;947;1247;skip
                1447;1847;1845;1850
at              353,299
write            VL
***

unit            x03s3o
back            x03m3p
erase
catchup
at              1010
write           For each of the five data points place the
                specified value of RL across the output of
                the Function Generator (just as you have
                done previously). The peak-to-peak voltage
                which you read from the SCOPE is VL. You
                have already determined that IL = VL/RL.
                Since you know VL and RL, the calculation
                of IL is simple division; a calculator has
                been provided for your convenience.
end
***

unit            x03s3p
draw            2111;2154;2754;2711;2111
at              2217
write            PLATO CALCULATOR
at              2312
write           Enter expression such as 5/7, 4.3/75, etc.
                         EXPRESSION:
                         PLATO CALCULATES:
at              1904
write           Press -DATA- if you would like to use the calculator to
                calculate IL. Otherwise press -NEXT- to enter IL directly.
***

unit            x03s3q
at              1822
erase           2
at              2432
erase           12
at              2539
erase           6
catchup
inhibit erase
arrow           2432
store           v70
```

```
ok
endarrow
calc      v71⇐v70
at        2539
show      v71
at        2612
write     Press -NEXT- to enter I_L above
pause
jump      x03m3p1
***

unit      x03s3r
calc      n100⇐140

entry     x03s3r1
calc      v(n100)⇐v56
add1      n100
calc      v(n100)⇐v131
add1      n100

------------------------------------------------------------------- part=2, block=1 ---------


          block 21,   x03end


unit      x03end
back      x03m3r
join      imode
jump      n47,x03end,x
course    n2
calcc     n2='ee244',
          nc(n21+1)⇐(nc(n21+1)$mask$o77777777770000000000)+o4603000000,
          nc(n21+1)⇐nc(n21+1)
erase
output    /// student has completed experiment ///
join      endunit
join      jmpmes
jumpout   cgeindex,quest1

entry     leave
end       lesson
***

unit      endunit
course    n2
jump      n2≠'ee244',leave,x
calc      nc(n21+7)⇐nc(n21+7)+ahelp
          vc(n21+6)⇐vc(n21+6)+atime/60000
***Incl.cge s.r. & terms sample,index,imode,comment,slides.
use       eex00,ck1
use       ck2
use       ck3
use       ck4
use       ck5
use       ck6
```

```
ckc               not found
ckc1              not found                 194     234     266 1477  300 1523 1263
ckc1w             not found                 981    1201    1399       1526
ckd               not found                1266    1479    1528
ckdi              not found                 177     218     255 1469  289 1497 1285
                                            181     184     187  225  190  230  222
ckd1w             not found                 259     262     293       296     :1500
endunit  x03end             1679           1288    1471    1519
imode             not found                  19    1673
jmpmes            not found                  29     308    1665
leave    x03end             1676           1674
x03end   x03end             1663           1681
x03m0a   x03m0a               27            735    1666
x03m1a   x03m1a               48             30      49
x03m1b   x03m1a               63             65
x03m1c   x03m1a               88             90     807     808  844  820  856  831
x03m1d   x03m1d              104             64     107     121
x03m1e   x03m1d              118             89     154
x03m2a   x03m2a              139            105
x03m2b   x03m2a              156            120     159     911       935     : 950
                                            154     201     968 1019  992 1066 1003
x03m2c   x03m2c              169           1127    1154
x03m2c1  x03m2c              192            160     990    1002      1020 1128 1064
x03m2d   x03m2c              198            179    1153    1169
x03m2d1  x03m2d1             212            196     241    1191 1238 1211 1272 1225
x03m2d1e x03m2d1             232            202    1209    1223      1286     :1293
x03m2e   x03m2d1             238            220
x03m2g   x03m2d1             251            236     274    1237      1319 1364 1346
x03m2g1  x03m2d1             264           1336    1345    1358
x03m2h   x03m2d1             270            257
x03m2i   x03m2d1             283            268     310    1407      1419     :1430
x03m2i1  x03m2d1             298           1406    1418    1428      1440
x03m3a   x03m3a              304            291
x03m3b   x03m3a              320            302     309     321
x03m3c   x03m3a              340            341
x03m3d   x03m3a              359            360
x03m3e   x03m3e              368            370
x03m3f   x03m3f              388            389    1473    1481
x03m3g   x03m3f              411            412    1478    1506      1530
x03m3h   x03m3f              431            434    1524    1527
x03m3i   x03m3i              467            468
x03m3j   x03m3i              486            433     487
x03m3k   x03m3i              499            500
x03m3l   x03m3i              519            520
x03m3m   x03m3m              544            545
x03m3n   x03m3m              571            573    1533    1551
x03m3o   x03m3m              605            607     709    1544
x03m3p   x03m3p              629            632
x03m3p1  x03m3p              678            608     704    1607
x03m3p2  x03m3p              697           1653
x03m3q   x03m3q              706            635     679
x03m3r   x03m3q              734            704     736
x03s1a   x03s1a              753            708    1664
x03s1a1  x03s1a              761             86
x03s1a2  x03s1a              768             86
x03s1a3  x03s1a              774             86
x03s1a4  x03s1a              781             86
```

```
x03s1a5   x03s1a      788      86    817    836    849    861
x03s1b    x03s1a      794      69
x03s1c    x03s1a      806     760
x03s1d    x03s1a      819     767
x03s1e    x03s1a      830     775
x03s1e1   x03s1a      838     850    862
x03s1f    x03s1a      843     787
x03s1g    x03s1a      855     792
x03s1h    x03s1h      865     106
x03s1h1   x03s1h      868     907
x03s1i    x03s1h      895     113    133    866    905
x03s1j    x03s1h      904     119
x03s2a1   x03s1h      910     154   1170   1252
x03s2a2   x03s1h      934     154   1065
x03s2a3   x03s2a3     948     154   1129
x03s2b    x03s2a3     967     161
x03s2c    x03s2a3     979     195    196
x03s2d    x03s2a3     989     985
x03s2e    x03s2a3    1001     983
x03s2e1   x03s2e1    1018     987
x03s2e2   x03s2e1    1033     631
x03s2e3   x03s2e1    1038    1021   1037   1504
x03s2e4   x03s2e1    1048
x03s2f    x03s2e1    1063     991
x03s2g    x03s2g     1085     986    987
x03s2g1   x03s2g     1126    1086
x03s2h    x03s2h     1151     984
x03s2h1   x03s2h     1167    1155
x03s2i    x03s2h     1190     203
x03s2j    x03s2h     1199     235    236
x03s2k    x03s2h     1208    1203   1206
x03s2l    x03s2h     1222    1205
x03s2m    x03s2m     1236    1204   1206
x03s2n    x03s2m     1249    1210   1268
x03s2n1   x03s2m     1261    1251
x03s2o    x03s2m     1270    1264   1290
x03s2o1   x03s2m     1283    1271
x03s2p    x03s2m     1292    1224
x03s2q    x03s2q     1317     240
x03s2r    x03s2q     1331     267
x03s2s    x03s2q     1335    1332
x03s2t    x03s2q     1344     268   1333
x03s2u    x03s2q     1357    1333
x03s2v    x03s2q     1376    1318   1359
x03s2w    x03s2w     1387     273
x03s2x    x03s2w     1397     301    302
x03s2y    x03s2w     1405    1401
x03s2z    x03s2w     1417    1402   1403
x03s2z1   x03s2w     1427    1403
x03s2z2   x03s2w     1439    1429
x03s3a    x03s3a     1456     328    342    377    396
x03s3b    x03s3a     1467     369
x03s3c    x03s3a     1475    1470
x03s3d    x03s3a     1483     390
x03s3e    x03s3e     1559     429
x03s3e1   x03s3e     1568     528    547    742
x03s3f    x03s3e     1580     530    549
```

```
x03s3g      x03s3a          1495                 391      1505      1517
x03s3h      x03s3a          1503                1501
x03s3i      x03s3a          1516                1501
x03s3j      x03s3a          1521                1498
x03s3k      x03s3e          1589                 529       548
x03s3k1     x03s3e          1596                 465
x03s3l      x03s3a          1532                 565       567
x03s3m      x03s3a          1543                 569
x03s3n      x03s3a          1550                 569
x03s3o      x03s3e          1606                 633
x03s3p      x03s3e          1622                 675
x03s3q      x03s3e          1634                 634       677       686
x03s3r      x03s3e          1655                 699
x03s3r1     x03s3e          1657                 699
ahelp                       1682
atime                       1683
data                         677
key                          677
msecs                        802
n                             84
nc                          1669      1669      1670      1670      1682        1682
n100                          79        81        82        84       727   729   728  1656   728
                            1658      1659      1660      1661
n101                          78        80        80        83
n2                          1667      1668      1680      1681
n21                         1669      1669      1670      1670      1682        1682  1683  1683
n33                          176       180       183       186       189   221   193   224   217
                             227       233       254       258       261   292   265   295   288
                             299       980      1200      1262      1265  1348  1284  1468  1287
                            1476      1496      1499      1518      1522        1525
n47                           30       178       179       182       185   196   188   219   191
                             220       223       226       231       236   260   256   263   257
                             268       290       291       294       297   982   302  1202   309
                            1264      1286      1400      1470      1478  1524  1498  1527  1501
                            1666
n51                           50        86        91       122       351   423   353   512   421
                             514       521       546       575       662   701   663   757   664
                             764       772       779       784       884         891  1557  1541
n52                           92       123       886       891
n53                           93       124       888
n54                          770       833
n55                          178       195       219       235       256   301   267  1152   290
n57                          649       704
n58                          574       649       651       699       700
n60                           51       213       223       252       260   562   285   564   294
                             566       568       758      1203      1332        1401
n61                           52       214       226       253       263   554   286   565   297
                             566       567       568       569       765        1204  1402  1333
n62                           53       170       182       215       231   985   287  1205   773
                            1400      1403
n63                           54       171       185       216       780         986  1206  1202
n64                           55       172       191       785       987
n65                          173       982       984
n66                          174
n67                          175       188       983
n70                          153       154
p                            853       853       863
```

```
v                         728       728      1658      1660
vc                       1683      1683
volts                     803
v102                       81        84
v103                       82        84
v130                      663       674
v131                      666       674      1660
v132                      674       689
v140                      726
v141                      726
v142                      726
v143                      726
v144                      726
v145                      726
v146                      726
v147                      726
v148                      726
v149                      726
v52                       664       667       755       810
v56                       688      1658
v70                      1644      1647
v71                      1647      1649
%                         667
Time                     902
V                        853       863
Volts                    901
Vma                    837
VL                      722

                                       lesson information


          lesson name = eex03

          starting date = 05/18/73

          last edited on 08/21/74 at 11.18.26

                by neal of course eecge

                at site 7, station 27

          author name = J.P. Neal

          department = EE

          telephone number = 333-4351

          discipline = EE

          grade level = Freshman

          descripion of lesson = The Operation and Uses of the Function Generator, Exact 251.
```

```
------------------------------------------------------------- part=1, block=a --------


     block 1a,  eex04id

stop
****     For Neal, CGERL, Room 248, EEB.

One line description of this lesson --

    The Operation and Uses of the DC Supply, Harrison 865B.

            Divisions of this Lesson:         Block    Unit

          Id for this file                    eex04id
          Experiment eex04:
            Objectives                        x04m0a   x04m0a
            Uses of dc supply                 x04m0a   x04m1a
            Constant v / constant i opn.      x04m2a   x04m2a
            Operation in floating mode        x04m3a   x04m3a
            Practical applications            x04m3h   x04m4a
            Optional studies                  x04m4d   x04m5a

          Final edit 21 aug 74 neal.

 *list    info
 *list    symbols
 *list    varian,charset,cgeindex,cgechar
 ****
 start
 finish   endunit
 write    (at,1010) Loading the CGE Character Set
 charset  cgeindex,cgechar
 erase
 dataon
 area     eex04
 ext      0

------------------------------------------------------------- part=1, block=b --------


      block 1b,  x04m0a


 unit     x04m0a
 restart
 join     imode
 jump     n47,x04m0a,x
 base
 next     x04m0b
 calc     n59⇐(-1)
 at       505
 write    The Operation and Uses of the Constant Voltage/Constant
```

```
                  Current Supply, Harrison Laboratories 865B
at          1010
write          When you have completed this experiment
            you should be able to:


            1) Determine the cases in which the DC SUPPLY
            can be used.

            2) Adjust the DC SUPPLY for constant current/
            voltage operation.

            3) Connect the DC SUPPLY in either a floating
            or a grounded mode, as the particular application
            may require.

            4) Use the DC SUPPLY in practical applications.
***

unit        x04m0b
back        x04m0a
next        x04m1a
lab         x04m4a
data        x04m5a
at          1210
write       Press -NEXT- for a CGE learning experience,

                  -LAB-   if you know all about this device,

                  -DATA-  for a do-it-yourself CGE sequence.
***

unit        x04m1a
back        n59,x04m0b,x04m3h,x04m5b
next        n59,x04m1b,x04m3h,x04m5b
join        n59-3,x04s1a,x
goto        n59,x,x04s0a,x04s0a,x
at          1611
write           Do you think that this device could be used
            to generate the 60 Hz. alternating current
            that is available from wall outlets?
arrow       1849
answer      (n,no,nope,NO,No)
at          2211
write       Right!  60 Hz. current is a periodic function of
            time.
wrong       (y,yes,YES,Yes)
at          2211
write       60 Hz current is not constant, it's a periodic
            function of time.
wrong
at          2211
write       y or n will suffice as an answer.
----------------------------------------------------------------- part=1, block=c ---------
```

```
     block 1c,  x04m1b


unit     x04m1b
back     n59,x04m1a,x04m3h,x04m5b
next     n59,x04m1c,x04m3h,x04m5b
join     n59-3,x04s1b,x
goto     n59,x,x04s0a,x04s0a,x
at       1611
write    Can this supply be used to ...
at       1811
write    Generate a constant (dc) voltage of 15 V ?
         Produce 10 volts across a 15 ohm resistor?
         Generate a constant current of 0.01 amp?
arrow    1854
answer   (YES,Yes,yes,y)
wrong    (NO,No,no,n,nope)
at       2211
write    Nope, it'll work.  Try it!
arrow    1954
answer   (NO,no,No,n)
wrong    (YES,Yes,yes,y)
at       2211
write    10 volts ÷ 15 ohms = 0.667 amp.  That's too much!
arrow    2054
answer   (no,NO,No,n)
wrong    (YES,Yes,yes,y)
at       2211
write    0.01 amp is below the minimum current of 0.1 amp
***

unit     x04m1c
back     n59,x04m1b,x04m3h,x04m5b
next     n59,x04m2a,x04m3h,x04m5b
join     n59-3,x04s1c,x
goto     n59,x,x04s0a,x04s0a,x
at       1211
write    The DC SUPPLY should be "ON".
         Is the pilot light glowing?
arrow    1339
answer   (yes,y,Yes,YES)
wrong    (no,NO,No,n)
at       1511
write    Call the lab assistant to check your supply.

------------------------------------------------------------------ part=1, block=d ---------


     block 1d,  x04m2a


unit     x04m2a
back     n59,x04m1c,x04m3g,x04m5b
next     x04m2b
jump     n59=3,x04m2b,x
```

```
at       611
write    The DC SUPPLY will operate as a constant voltage
         source if the load current remains less than the
         setting of the CURRENT dial.
at       1011
write    Or the DC SUPPLY will operate as a constant current
         source so long as the load voltage is less than the
         setting of the VOLTAGE dial.
at       1411
write    In any case, the load current (I_L) will never be
         greater than the CURRENT dial setting;  and,
         the load voltage (V_L) will never be greater than
         the VOLTAGE dial setting.  The mode of operation
         of the DC SUPPLY is determined by the setting
         of these dials and the load resistor only!!
         The setting of the METER switch has no effect on
         this operation!!!

----------------------------------------------------------------- part=1, block=e -----------


        block 1e,  x04m2b


unit     x04m2b
back     x04m2a
next     n59,x04m2c,x04m3h,x04m5b,x04m2c
join     n59-3,x04s2a,x
goto     n59,x,x04s0a,x04s0a,x
at       1411
write    If the DC SUPPLY is set at 20 volts and
         0.15 amp, and then a 100 ohm load is placed
         on the output, what will be the resultant load
         current and voltage ?
at       2011
write    I_L=__________amp.    V_L=__________volts.
arrow    2014
specs    nookno
ansv     0.15,1%
at       2311
write    Right !   The DC SUPPLY will not allow the load
         current to become greater than the dial setting.
store    v55
no
join     v55>0.15,x04s2b,x04s2c
arrow    2035
ansv     15,,1
at       2611
write    Right !  The DC SUPPLY is in constant current mode.
store    v55
no
at       2611
write    You got I_L right, now just use Ohm's law!
***

unit     x04m2c
```

```
help    x04s2d
next    x04m2d
goto    n59,x,x04s0a,x04s0a,x
at      810
write   Let's try to show this by experimentation.
at      1210
write   Set up the DC SUPPLY for 20 volts and 0.15 amperes.
at      3110
write   -HELP- is available.
***

unit    x04m2d
pack    n33,++++++++++++++++(hi) (fghijk)+++++
join    ckd
jump    n47,x04s2e,x
goto    n59-10×n47,x04m3a,x04m3h,x04m5b,x04m5b,x04m5b,x04s2f

-------------------------------------------------------------- part=1, block=f ---------


        block 1f,  x04m3a


unit    x04m3a
back    n59,x,x04m3h,x04m5b
next    n59,x04m3b,x04m3h,x04m5b,x04m3b
join    n59-3,x04s3a,x
goto    n59,x,x04s0a,x04s0a,x
at      1511
write      Connect the sensor cable of the RESISTOR BOARD,
        and then drive the 100 ohm resistor from the
        DC SUPPLY in the following fashion:

           Connect the (+) output to Terminal 3.

           Connect the (-) output to GROUND.

           Connect the (-) output to Terminal 4.
***

unit    x04m3b
pack    n33,0012000000000200000000000120+00
join    ckc
jump    n47,x04m3a,x04m3c
***

unit    x04m3c
back    n59,x04m3a,x04m3h,x04m3a
next    n59,x04m3d,x04m3h,x04m5b
at      811
write      With the 100 ohm resistor connected the current
        will not exceed 0.15 amp, at any voltage setting.
        Also, the voltage will never exceed the 20 volts
        despite the current setting.

           Experiment with this until you can verify these
```

```
            statements.
               Can you verify the above ?
  arrow     1642
  answer    (YES,Yes,yes,y)
  wrong     no
  write     Call the lab instructor.
  join      imode
  jump      n59-4*n47,x04m3d,x04m3h,x04m5b,x04m3c
-----------------------------------------------------------------------------
------------------------------------------------------- part=1, block=g ------------


          block 1g.  x04m3d


  unit      x04m3d
  back      n59,x04m3c,x04m3h,x04m5b
  next      n59,x04m3e,x04m3h,x04m5b
  join      n59-3,x04s3b,x
  goto      n59,x,x04s0a,x04s0a,x
  at        2211
  write        If you had as many power supplies of this type
            as you wanted could you generate a 1.5 ampere
            current ?
  arrow     2421
  answer    (NO,No,no,n)
  ***

  unit      x04m3e
  back      n59,x04m3d,x04m3h,x04m5b
  next      n59,x04m3f,x04m3h,x04m5b,x04m3f
  join      n59-3,x04s3c,x
  goto      n59,x,x04s0a,x04s0a,x
  jump      n59=3,x04m3f,x
  ***

  unit      x04m3f
  back      x04m3e
  at        809
  write     Set the METER dial to display the load current.
  pause
  pack      n33,+++++++++++++++v+++++++
  join      ckd
  jump      n59-10*n47,x04m3g,x04m3h,x04m5b,x04m5b,x04m5b,x04m3f
  ***

  unit      x04m3g
  term      test
  zero      n59
  jump      x04m3h
-----------------------------------------------------------------------------
------------------------------------------------------- part=1, block=h ------------
```

```
block 1h,  x04m3h


unit     x04m3h
at       811
write       To review any of these topics press the
         following keys:

         a)  Definitions of direct current (dc).
         b)  Power supplies and glowing lights.
         c)  Constant voltage and constant current mode.
         d)  Power supply load connections.
         e)  Multiple power supply operations.
         f)  Functions of the METER dial.
         g)  Voltage and current limitations.
         h)  Operation of the VOLTAGE and CURRENT controls.

            You will be automatically returned to this
         page after each review unit.

         Topic ?

         When you are finished press -DATA- for the final test.
data     x04m4a
goto     n59,x,x,x04s0a
base
arrow    2319
long     1
match    n60,a,b,c,d,e,f,g,h
jump     n60,x,x04m1a,x04m1c,x04m2a,x04m3a,x04m3d,x04m3e,x04m1b,x04s2d
at       2511
write    Just type the letter.
***

unit     x04m4a
base
join     imode
jump     n47,x04m4a,x
calc     n60⇐-2
jump     x04m4b
***

unit     x04m4b
back     x04m0a
at       810
write       Set the DC SUPPLY to produce the following output:

                A 15V dc signal across the 500 ohm resistor
            on the resistor circuit board.

               The DC voltage generated should be negative
            (-) with respect to ground.

               The resistor itself should be connected
            such that terminal 7 is connected to ground.

               Set the meter on the DC supply to monitor the
```

```
                load voltage.
        pause
        pack    n33,000000ab0000a000000000000ab0+00
        join    ckow
        jump    n47,x,x04m4b1
        next    x04m4b
        ***

        unit    x04m4b1
        pack    n33,+++++++++++++++(fg)+++++
        join    ckd
        jump    n47,x04s4a,x
        jump    x04m4c
        ***

        unit    x04m4c
        join    imode
        jump    n47,x04m4c,x
        at      811
        write      Can the power supply be used to generate:

                1)  A 48 volt dc signal ?          (yes/no)

                2)  How about 17 volts ac ?

                3)  A constant current of 0.4 amperes ?
        arrow   1039
        answer  (NO,No,no,n)
        wrong   (YES,yes,y,Yes)
        add1    n60
        arrow   1241
        answer  (NO,No,no,n)
        wrong   (YES,Yes,yes,y)
        add1    n60
        arrow   1450
        answer  (YES,Yes,yes,y)
        next    n60,x,x,x04s4d
        wrong   (NO,No,no,n)
        add1    n60

----------------------------------------------------------------- part=1, block=i -----------


           block 1i,  x04m4d


        unit    x04m4d
        at      814
        write      Set the DC SUPPLY to generate 20 V dc
                with the current limited to 0.3 A.

                   Set the METER to measure output voltage.
        pause
        pack    n33,+++++++++++++++a(hi)(lmn)+++++
        join    ckd
        jump    n47,x04s4b,x
jump    n47,x04s4c,x
jump    x04m4e
***

unit    x04m4e
join    imode
jump    n47,x04m4e,x
at      411
write      If you were to set the dials of the supply to
        the following positions-

        1)  METER       - volts
        2)  VOLTAGE     - 20 volts
        3)  CURRENT     - 0.1 amperes

           Would the supply be in constant voltage or
        constant current operation with a load of
        100 ohms ?               (type letter)

                      a)  Constant current
                      b)  Constant voltage
arrow   1322
answer  (A,a)
wrong   (B,b)
add1    n60
***

unit    x04m4f
at      809
write      If you required more current than the DC SUPPLY
        could furnish, could you connect two DC SUPPLIES
        in parallel ?

           If you required more voltage than the DC SUPPLY
        could furnish, could you connect two DC SUPPLIES
        in series ?
next    n60,x04end,x04end,x04s4d
arrow   1034
answer  (NO,No,no,n)
wrong   (YES,yes,Yes,y)
add1    n60
arrow   1434
answer  (YES,Yes,yes,y)
wrong   (NO,No,no,n)
add1    n60
***

unit    x04m5a
back    x04m0a
base
at      620
write   Do it your self study.
at      811
write   Choose any method of study you wish!!

        Enter   i   for only information
                q   for only questions,  or
```

```
                     b    for both information and questions
      arrow     1411
      long      1
      answer    (I,i)
      calc      n59⇐1
      answer    (Q,q)
      calc      n59⇐3
      answer    (B,b)
      calc      n59⇐2
      ***

      unit      x04m5b
      back      x04m5a
      base
      at        611
      write     (Press -BACK- to change study mode.)
      join      x04m3h
      arrow     2019
      long      1
      match     n60,a,b,c,d,e,f,g,h
      next      n60,x,x04m1a,x04m1c,x04m2a,x04m3a,x04m3d,x04m3e,x04m1b
------------------------------------------------------------------------ part=1, block=j -----------
```

```
          block 1j.  x04s0a


      unit      x04s0a
      *         dummy unit to end goto's
      ***

      unit      x04s1a
      at        711
      write        The DC SUPPLY is used to generate direct
                current: that is, the current (or voltage)
                generated is constant for a given load, i.e.
                it is not a periodic function of time.

                   Of course the output of the device is
                adjustable, but for any setting it will not
                generate anything but a constant voltage and
                current, if the load is constant.
      ***

      unit      x04s1b
      at        711
      write     Note that this supply can only generate voltages
                up to 40 volts dc.  Also, the maximum current
                capacity of this supply is 0.5 amperes.
                Voltages or currents greater than these limits
                cannot be produced.

                However, the supply will not operate at all if
                the CURRENT dial is set less than about 0.1 amp.
      ***
```

```
unit    x04s1c
at      811
write      Turn on the DC SUPPLY by throwing the
        small toggle switch on the left of the supply.
        The small, red pilot light should glow.
***

unit    x04s2a
at      611
write   Calculating I_L and V_L is easy.  Just assume that
        the supply is in either constant voltage or
        constant current operation.  Then, use R_L to
        calculate the remaining V_L or I_L.  If the V or
        I is not greater than it's limit, you have the
        solution.  If not, the supply is operating in
        the other mode.
***

unit    x04s2b
at      2311
write   I_L cannot be greater than the current limit.
***

unit    x04s2c
at      2311
write   No, if I_L were really that, what would V_L be?
        And which parameter (I or V) would be limiting?
```

```
------------------------------------------------------------------- part=1, block=k ----------
```

```
     block 1k,  x04s2d
```

```
unit    x04s2d
back    n59,x04m2c,x04m3h,x04m5b
next    n59,x04s2d2,x04m3h,x04m5b,x04s2d2,x04m5b
join    n59-3,x04s2d1,x
goto    n59,x,x04s0a,x04s0a,x
jump    n59=3,x04s2d2,x
***

unit    x04s2d1
at      810
write      To set the power supply to a given voltage and
        current limit output, first short the +(red)
        and -(black) terminals of the DC SUPPLY
        with a test lead.

           With the METER switch on AMPS, adjust the
        CURRENT control to the desired current limit.

           Remove the test lead from the DC SUPPLY
        terminals and turn the METER switch to VOLTS.
        Then adjust the VOLTAGE control to the desired
        output voltage limit.

           One additional note: Be sure you are reading
        the correct meter scale when setting the
        current and voltage limits.
***

unit    x04s2d2
back    n59-3,x04s2d,x04m5b
next    n59,x04m2c,x04m3h,x04m5b
at      410
write   To set the output current limit of the DC SUPPLY,
        which of the following is necessary?

        a) The + output terminal of the supply should
        be grounded.

        b) The + and - terminals of the supply should
        be shorted together.

        c) The + and - terminals of the supply should
        be left open circuited.
arrow   1520
specs   nookno
answer  (b,B)
at      1705
write      Right! But remember to disconnect the short when
        setting the output voltage limit.
wrong   (a,A)
at      1705
write      No! The DC SUPPLY is a floating supply and hence
        neither the + or - terminals are internally
        connected to ground.
wrong   (c,C)
at      1705
write      No! Only when you are setting the voltage limit
        is it necessary that the output terminals be
        open circuited.
no
at      1705
write   Just type the letter of your response.
***

unit    x04s2e
next    x04m2c
pack    n33,++++++++++++++++ij++++
join    ckd1
jump    n47,x04s2f,x
at      1116
write   You are reading the wrong meter scale!!
***

unit    x04s2f
next    x04s2d
at      1005
write      You have incorrectly set the VOLTAGE and/or
        CURRENT dials. You will receive help when you
```

```
                you press -NEXT-.

----------------------------------------------------------------------- part=1, block=1 ----------


          block 11,  x04s3a


      unit      x04s3a
      at        811
      write        The output of the DC SUPPLY is available
                at the red and black jacks in the lower right
                area of the panel.  The silver jack at the far
                right is a chassis ground and may be connected
                to either the red or black jack as required.
      ***

      unit      x04s3b
      at        809
      write        Note carefully that two DC SUPPLIES cannot
                be connected in parallel to achieve a greater
                current capability.  The reason for this is
                simple but important.

                   If two DC SUPPLIES are connected in parallel,
                one supply will try to drive the other and a
                large current will flow along the low resistance
                wires between the supplies.  This does not
                happen when two DC SUPPLIES are connected in series
                with a current limiting load; thus, they can be
                connected in series to generate larger voltages
                than either supply acting alone.
      ***

      unit      x04s3c
      at        811
      write        Note the METER switch located just right of
                the panel meter.  This switch controls the
                indications of the meter.  The meter will
                measure either load current or load voltage,
                depending upon the position of the switch.

                   Note that this switch has NO EFFECT on the
                operation of the supply, it simply indicates the
                actual terminal voltage or current.
      ***

      unit      x04s4a
      at        1011
      write     Remember...

                          Set the output voltage to 15 V dc.

                     (It will be necessary for you to increase
                the output current limit until the voltage
                across the 500 ohm resistor is 15 V dc.)
```

```
                 Monitor the output voltage!
next        x04m4a
***

unit        x04s4b
pack        n33,+++++++++++++++a(ijk)q+++++
join        ckd1
jump        n47,x04s4c,x
at          1116
write       You are reading the wrong meter scale!!
next        x04m4d
***

unit        x04s4c
join        x04s2f
pause
erase
join        x04s2d1
pause
jump        x04m4d
```

```
------------------------------------------------------------------ part=1, block=m -----------
```

```
        block 1m,  x04end


unit        x04s4d
at          1211
write          You appear to be having some trouble.

               Press -NEXT- for a chance to review.
c           A student failing the prof. test has(n59⇐-1).
next        n59,x04m5a,x04m3h,x04m5a
***

unit        x04end
back        x04m5a
join        imode
jump        n47,x04end,x
course      n2
calcc       n2='ee244',
            nc(n21+1)⇐(nc(n21+1)$mask$o77777777770000000000)+o4603000000,
            nc(n21+1)⇐nc(n21+1)
erase
output      /// student has completed experiment ///
join        endunit
join        jmpmes
jumpout     cgeindex,quest1

entry       leave
end         lesson
***

unit        endunit
```

```
624 course  n2
625 jump    n2≠'ee244',leave,x
626 calc    nc(n21+7)⇐nc(n21+7)+ahelp
627         vc(n21+6)⇐vc(n21+6)+atime/60000
628 ***Incl.cge s.r. & terms sample,index,imode,comment,slides.
629 use     eex00,ck1
630 use     ck2
631 use     ck3
632 use     ck4
633 use     ck5
634 use     ck6
    ckc          not found                208
    ckcw         not found                309
    ckd          not found                189     254     315       348
    ckd1         not found                528     586
    endunit x04end         623             21     617
    imode        not found                 31     226     290       320  609  354
    jmpmes       not found                618
    leave   x04end         620            625
    x04end  x04end         607            380     380     610
    x04m0a  x04m0a          29             32      52     296       391
    x04m0b  x04m0a          51             34      62
    x04m1a  x04m0a          61             53      84     284       418
    x04m1b  x04m1b          83             63     111     284       418
    x04m1c  x04m1b         110             85     125     284       418
    x04m2a  x04m2a         124            112     147     284       418
    x04m2b  x04m2b         146            126     127
    x04m2c  x04m2b         176            148     148     471       495       526
    x04m2d  x04m2b         187            178
    x04m3a  x04m3a         193            191     209     212       212  418  284
    x04m3b  x04m3a         206            195     195
    x04m3c  x04m3a         211            209     227     230
    x04m3d  x04m3d         229            213     227     242       284       418
    x04m3e  x04m3d         241            231     249     284       418
    x04m3f  x04m3d         248            243     243     246       255
    x04m3g  x04m3d         257            125     255
    x04m3h  x04m3h         262             62      63      84  112   85  148  111
                                          191     194     195  227  212  230  213
                                          231     242     243  414  255  471  260
                                          472     495     605
    x04m4a  x04m3h         288             54     278     291       582
    x04m4b  x04m3h         295            293     311
    x04m4b1 x04m3h         313            310
    x04m4c  x04m3h         319            317     321
    x04m4d  x04m4d         341            590     598
    x04m4e  x04m4d         353            351     355
    x04m4f  x04m4d         372
    x04m5a  x04m4d         390             55     410     605       605       608
    x04m5b  x04m4d         409             62      63      84  112   85  125  111
                                          148     191     191  195  191  213  194
                                          227     230     231  255  242  255  243
                                          255     471     472       472  445  494
    x04s0a  x04s0a         420             65      65      87  114   87  150  114
                                          150     179     179  233  197  233  197
                                          245     245     279       474       474
    x04s1a  x04s0a         423             64
    x04s1b  x04s0a         434             86
```

```
x04s1c    x04s0a           445                 113
x04s2a    x04s0a           451                 149
x04s2b    x04s0a           461                 166
x04s2c    x04s0a           465                 166
x04s2d    x04s2d           470                 177       284       494          534
x04s2d1   x04s2d           477                 473       596
x04s2d2   x04s2d           493                 472       472       475
x04s2e    x04s2d           525                 190
x04s2f    x04s2d           533                 191       529       593
x04s3a    x04s3a           540                 196
x04s3b    x04s3a           548                 232
x04s3c    x04s3a           563                 244
x04s4a    x04s3a           574                 316
x04s4b,   x04s3a           584                 349
x04s4c    x04s3a           592                 350       587
x04s4d    x04end           600                 337       380
ahelp                      626
atime                      627
nc                         613       613       614       614       626          626
n2                         611       612       624       625
n21                        613       613       614       614       626          626  627  627
n33                        188       207       253       308       314          347  585  527
n47                         32       190       191       209       227  310     255  316  291
                           321       349       350       355       529          587       610
n59                         35        62        63        64        65   86      84   87   85
                           111       112       113       114       125  149     127  150  148
                           179       191       194       195       196  213     197  227  212
                           230       231       232       233       242  245     243  246  244
                           255       259       279       403       405  472     407  473  471
                           474       475       494       495       605
n60                        283       284       292       330       334  370     337  380  339
                           384       388       417       418
vc                         627       627
v55                        134       166       171
%                          160
```

```
                              lesson information

          lesson name = eex04

          starting date = 03/29/73

          last edited on 08/21/74 at 11.19.15

                    by neal of course eecge

                    at site 7, station 27

          author name = J P Neal

          department = EE

          telephone number = 333-4351

          discipline = EE
```

grade level = Freshman

descripion of lesson = The Operation and Uses of the DC Supply, Harrison 865B.

```
    block 1a,  eex05id

stop
****    For Neal, CGERL, Room 248, EEB.

One line description of this lesson --

   The Operation and Uses of the Vacuum Tube Voltmeter, HP400D.

          Divisions of this Lesson:      Block    Unit

        Id for this file                 eex05id
        Experiment eex05;
          Objectives                     eex05id  x05m0a
          Properly set range dial        x05m1a   x05m1a
          Properly connect vtvm          x05m1a   x05m2a
          Determine uses of vtvm         x05m2d   x05m3a
          Convert rms to p-p             x05m2d   x05m4a
          Predict vtvm indications       x05m4h   x05m5a
          Final test                     x05m5n   x05m6a

        Final edit 21 aug 74 neal.

 *list   info
 *list   symbols
 *list   varian,charset,cgeindex,cgechar
 ****
 start
 finish  endunit
 write   <at,1010> Loading the CGE Character Set
 charset cgeindex,cgechar
 erase
 dataon
 area    eex05
 ext     0
 ***

 unit    x05m0a
 base
 restart
 next    x05m1a
 join    imode
 jump    n47,x05m0a,x
 at      507
 write   THE OPERATION AND USES OF THE VACUUM TUBE VOLTMETER,
                    Hewlett Packard Model 400D

            In this experiment, you should learn to:

         1)     Adjust the RANGE dial of the VTVM to measure
         voltages accurately.
```

```
            2)     Properly connect the VTVM to the terminal
            whose voltage-to-ground is to be measured.

            3)     Determine those voltages which can and cannot
            be accurately measured on the VTVM.

            4)     Convert Vrms to Vpp, and understand the
            relationship between the two for sinusoidal waveforms.

            5)     Predict the VTVM indication for simple
            non-sinusoidal periodic waveforms.

------------------------------------------------------------ part=1, block=b ----------


        block 1b,  x05m1a


unit     x05m1a
back     x05m0a
next     x05m1b
at       510
write       Voltage measurements are displayed on the
         large panel meter.  The RANGE switch (below the
         meter) is used to scale the input voltage to
         allow more accurate readings.

            The setting of the RANGE switch determines the
         largest rms voltage voltage that can be measured
         at that setting.  For most accurate measurements,
         the pointer should indicate in the range between
         30 to 100 % of full scale.
***

unit     x05m1b
back     x05m1a
next     x05m1b1
help     x05s1a
at       1010
write       Set the RANGE dial to accurately measure a
         45 rms volt signal.


                       -HELP- is available.
***

unit     x05m1b1
help     x05s1a
pack     n33,+++++++++++++++++++++k+
join     ckdw
jump     n47,x,x05m2a
next     x05m1b
***

unit     x05m2a
```

```
 back     x05m1b
 next     x05m2b
 at       510
 write       The voltage applied between the RED and BLACK
          jacks on the left side of the voltmeter marked
          INPUT is the voltage that will be measured by
          the voltmeter.  The BLACK jack is internally
          connected to ground.  The RED jack is connected
          to the point of interest.  Note that the
          resultant voltage is always measured with
          respect to ground, because the BLACK jack is
          internally grounded.
 ***

 unit     x05m2b
 back     x05m2a
 next     x05m2c
 at       1010
 write       If you were to measure a voltage with respect
          to ground at some point "X" , which color terminal
          on the VTVM would you connect to "X" ?
 arrow    1610
 specs    bumpshift
 answer   red
 at       2010
 write       RIGHT ! And that's the only connection required.

             However, if you were to measure a voltage in an
          UNGROUNDED circuit you would have to connect the
          black terminal of the VTVM to the circuit also.
 wrong    black
 at       1810
 write       The black jack is already connected to ground.
 no
 at       1810
 write       You only need to write the color of the jack.
 ***

 unit     x05m2c
 back     x05m2b
 next     x05m2d
 at       510
 write       Connect the VTVM to display an indication for
          the 0.1V P-P  CAL OUT  jack on the SCOPE.
------------------------------------------------------------ part=1, block=c ----------


        block 1c,  x05


 unit     x05m2d
 back     x05m2c
 next     x05m3a
 help     x05s1a
 at       510
```

```
write        Adjust the RANGE switch to accurately measure
          the output from the 0.1V P-P  CAL OUT  jack.

                What indication do you read ?
at        1429
write     -HELP- is available
arrow     843
specs     nookno
ansv      0.056,.002
at        1015
write     Excellent !  A very close reading.
ansv      0.056,.01
at        1015
write     That's a good reading.
wrongv    0.056,.04
at        1015
write     Try to get a little closer reading.
wrongv    0.0056,.001
at        1015
write     You've got the wrong jack !
no
at        1015
write     You're way off, better try again.
***

unit      x05m3a
back      x05m3d
next      x05m4a
at        305
write        The nonsinusoidal voltage from the SCOPE that you just
          measured was at a frequency of 1000 Hz. Furthermore, the
          scale reading was equal to or less than the voltage label.

             Only frequencies greater than 10 Hz but less than
          4 MHz ( 4 x 10^6 ) can be measured accurately.

             Also, only indications larger than about 0.001 and
          less than 300 can be read accurately.
at        1508
write        Can the VTVM be used to measure:

          1)  A 17 V p-p 1000 Hz signal ?          (yes/no)

          2)  The 115 volt ac output of a wall receptacle ?

          3)  A 43 volt dc signal ?
arrow     1739
specs     bumpshift
answer    yes
arrow     1957
specs     bumpshift
answer    yes
arrow     2133
specs     bumpshift
answer    no
no
at        2422
```

```
write   REMEMBER: dc is 0 Hz.
***

unit    x05m4a
restart
base
join    imode
jump    n47,x05m4a,x
at      507
write      This task will examine the relationship between
        the peak-to-peak voltage measurement on the SCOPE,
        and the R.M.S. SINE indication on the VTVM, for the
        same ac signal.

           In electrical engineering, the term ac for
        alternating current usually refers to a sinusoidal
        current with a zero average value.

           To begin our experiment, we need an ac source.
        Hence, set the AUDIO OSCILLATOR to an output frequency
        of 2000 Hz.
pause
jump    key=back,x05m3a,x

entry   x05m4a1
pack    n33,++++++++++++++++++<b(uv)c(bc)>+
join    ckd
jump    n47,x05s4a,x05m4b
***

unit    x05m4b
at      1007
write      Measure this signal with the VTVM, as follows:

           First, set the VTVM range to allow the most accurate
        measurement of a 25 rms volt sinusoidal signal.
pause
jump    key=back,x05m4a,x
pack    n33,+++++++++++++++++++++j
join    ckd
jump    n47,x05s4b,x05m4c
------------------------------------------------------------ part=1, block=d ---------


        block 1d,  x05m4c


unit    x05m4c
at      510
write      Connect the output of the AUDIO OSCILLATOR
        to the VTVM.

           The VTVM is internally grounded and only
        requires one connection.
```

```
           Be sure that the AUDIO OSCILLATOR ground link
        is connected and tightened.
pause
jump    key=back,x05m4b,x
pack    n33,000000000000b0000000000000aba
join    ckcw
jump    n47,x,x05m4d
next    x05m4c
***

unit    x05m4d
back    x05m4c
next    x05m4d1
at      510
write      Carefully adjust the output AMPLITUDE of the
        AUDIO OSCILLATOR to cause a 25 rms volt indication
        on the VTVM.
***

unit    x05m4d1
pack    n33,++++++++++++++++++(rs) (bc) (bcuv) j
join    ckd
jump    n47,x,x05m4e
pack    n33,++++++++++++++++++(tu) (bc) (bcuv) j
join    ckd1
goto    n47,x,x05s4c
pack    n33,++++++++++++++++++(pq) (bc) (bcuv) j
join    ckd1
goto    n47,x,x05s4d
at      510
write      You're way off! The frequency should still
        be 2000 Hz. The VTVM should be set to measure
        25 RMS volts. The Audio Oscillator AMPLITUDE
        should be adjusted to cause an indication of
        25 rms volts on the VTVM.
pause
jump    x05m4d1
***

unit    x05m4e
back    x05m4d
next    x05m4f
erase
catchup
at      1510
write      Now that you have set the AUDIO OSCILLATOR
        correctly, do not change any of its controls unless
        specifically directed.
***

unit    x05m4f
back    x05m4e
next    x05m4g
at      510
write      The ac voltage you have set is measured
        on the VTVM in rms (root-mean-square) volts.
```

```
                  Root-mean-square volts are defined as follows:
at          1019                                       1/2
write       V    = [ (1/T) ∫^T  (v(t))^2  dt ]
             rms           0
at          1210
write       where T = the period of v(t), and v(t) is in volts.
pause
at          1410
write          Note that root-mean-square is descriptive
            of the above formula, as follows:

            ROOT = square root of the bracketed expression
                         T
            MEAN = 1/T × ∫  (    ) dt of the following integrand
                         0
            SQUARE = squared time function = (v(t))^2
***

unit        x05m4g
back        x05m4f
at          706
write          Set the SCOPE to measure an ac voltage on the A
            channel with A VOLTS at 100 V FULL SCALE.

               Of course, the A PREAMP should be AC coupled and
            the SWEEP should be internally triggered by AC signals.

            RECALL: DO NOT TOUCH THE AUDIO OSCILLATOR DIALS!
pause
pack        n33,++p++f+ab+++++++++++++
join        ckd
jump        n47,x05s4e,x05m4h
-------------------------------------------------------------- part=1, block=e ---------


        block  1e,  x05m4h

unit        x05m4h
at          710
write          Connect the output of the AUDIO OSCILLATOR
            to the A INPUT of the SCOPE.

               The SCOPE is grounded by ground links and also
            requires only one connection.
pause
pack        n33,0000000000a00b0000000000ba+0
join        ckcw
jump        n47,x,x05m4i
next        x05m4h
***

unit        x05m4i
base
back        x05m4e
```

```
next      x05m5a
calc      n120⇐-1
at        510
write     What is Vpp (from the SCOPE)?  ____    volts
arrow     540
store     v55
ansv      70,4
endarrow
calc      v56⇐25.0/v55
at        710
write     On the basis of your measurements:

                Vrms =    -----    × Vpp
join      x05s4f

entry     x05m4i1
inhibit   erase
data      x05s4f
back      x05m4e
arrow     922
ansv      v56,10%
no
at        1110
write     Vrms = VTVM indication = 25

          Vpp = Scope Reading = ⟨s,v55⟩ volts

          Vrms = ?? × Vpp

          Press -NEXT- to clear your answer, then...
          ...Press -DATA- to re-use the calculator.
endarrow
calc      n120⇐0
at        1110
write     And   Vpp =    -----    × Vrms
join      x05s4f

entry     x05m4i2
inhibit   erase
data      x05s4f
back      x05m4e
arrow     1122
ansv      v55/25,2%
no
at        1315
write     Press -NEXT- to clear your answer then ...
          ... press -DATA- to re-use the calculator
endarrow
at        1310
write     NOTE:  These conversion factors are only valid
          for a sinusoidal wave symmetric about 0 volts.

          Let's take a look at what the theoretical values
          are for these conversion factors.
***

unit      x05m5a
```

```
term     rms
back     x05m4i
next     x05m5b
erase
catchup
at       210
write       NOTE: Study this sequence carefully.
         You'll be asked a problem based on this method.
at       715
write       Consider an ac or simple sine wave:

                       v(t) = sin(ωt)
join     x05s5b
delta    .1
funct    (sin(v55)),v55
***

unit     x05m5b
back     x05m5a
next     x05m5c
at       305
write       Now let's square v(t):

                 (v(t))^2 = ( sin(ωt) )^2
join     x05s5b
delta    .1
funct    (sin(v55))^2,v55
pause
join     x05s5b1
pause
calc     v60⇐sqrt(v59)
at       2219
write    Vrms = √Y1  = ⊲z,v60,3.3⊳
hbar     2π,.707,-
graph    2.1π,.707,Vrms
pause
at       2505
write       The average of the squared wave is 0.5

            The square root of 0.5 is 0.707

            The value of Vrms = 0.707 for v(t) = sin ωt compares
         with Vpp = 2.0 which is read on the Scope for v(t).
------------------------------------------------------------- part=1, block=f --------


      block 1f,  x05m5c


unit     x05m5c
back     x05m5b
next     x05m5d
at       709
write       Generally, as applies for any simple sine wave,
         the following ratios are established:
```

```
                  Vpp / Vrms = 2√2 = 2.828

                  V0p / Vrms = 2√2 / 2 = √2 = 1.414

                 Or, inversely:

                  Vrms / Vpp = √2 /4 = 0.354

                  Vrms / V0p = 1/√2 = √2/2 = 0.707
        ***

        unit    x05m5d
        back    x05m5a
        next    x05m5e
        at      205
        write      The rms value of a periodic voltage is the square
                root of the average of the squared voltage.

                   Calculate Vrms for the following wave:

                Vrms =          rms volts    (Press -BACK- to review)
        at      1235
        write   y(t) =  1       0 < t < T/2
                     = -1    T/2 < t < T
        join    x05s5b
        gdraw   0,1;π,1
        gdraw   ;π,-1
        gdraw   ;2π,-1
        gdraw   ;2π,0
        arrow   712
        ansv    1.0
        no
        at      2505
        write      1² is the same as (-1)², the average over one
                period of the constant 1.0 volt is 1.0 volt, and
                the square root of 1. is 1.
        ***

        unit    x05m5e
        restart
        back    x05m5d
        next    x05m5e1
        join    imode
        jump    n47,x05m5e,x
        at      505
        write      Although the VTVM scales are calibrated in the unit
                R.M.S. VOLTS for a simple SINE wave, the VTVM does not
                indicate the root-mean-square voltage for any signal.

                   The actual indication on the VTVM is related to the
                input signal by the following formulae:
        at      1207
        join    x05s5a
        ***

        unit    x05m5e1
```

```
back     x05m5e
next     x05m5e2
at       707
write       As noted, the VTVM indication for a pure sine wave
         is its rms voltage, and this is not true generally
         for every non-sinusoidal waveshape.

            The relation between the waveshape of a periodic
         voltage applied at the INPUT of the VTVM, the responsive
         position of the pointer of the VTVM, and the scale
         reading indicated by the pointer can be understood
         more clearly by tracing the effects of the INPUT voltage
         through a schematic diagram of the VTVM.
---------------------------------------------------------------------- part=1, block=g ---------


         block 1g,  x05m5e2


unit     x05m5e2
back     x05m5e1
next     x05m5e3
join     x05s5e2
at       1605
write       The signal at the INPUT terminals of the VTVM is:

         vAA' = v(t)
pause
mode     erase
at       1605
write       The signal at the INPUT terminals of the VTVM is:

         vAA' = v(t)
mode     write
at       1605
write    vAA' = v(t)

            The capacitor blocks the average value so at BB'
         only the ripple remains:

         vBB' = v(t)- Vav, where Vav = 1/T ∫_0^T v(t)dt
at       190,456
write    B
at       190,344
write    B'
pause
mode     erase
at       1805
write       The capacitor blocks the average value so at BB'
         only the ripple remains:

         vBB' = v(t)- Vav, where Vav = 1/T ∫_0^T v(t)dt
mode     write
at       1805
write    vBB' = v(t)- Vav, where Vav = 1/T ∫_0^T v(t)dt
```

```
502            The full-wave rectifier converts all negative values
503         to positive values, so the fully-rectified ripple
504         at CC' is:

505         vCC' = |v(t) - Vav|
506 size    7
507 at      352,382
508 write   }
509 size    0
510 at      384,400
511 write   Full-wave
512         Rectifier
513 at      235,321
514 write   C
515 at      333,321
516 write     C'
517 pause
518 mode    erase
519 at      2005
520 write      The full-wave rectifier converts all negative values
521         to positive values, so the fully-rectified ripple
522         at CC' is:

523         vCC' = |v(t) - Vav|
524 mode    write
525 at      292,319
526 write   M
527 at      2005
528 write   vCC' = |v(t) - Vav|

529            The d'Arsonval mechanism (M), because of its inertia,
530         cannot respond to a frequency greater than 3 Hz, so
531         the pointer responds to the average value of vCC' :

532         VTVM response = 1/T ∫0T |v(t)-Vav|dt

533 pause
534 mode    erase
535 at      2205
536 write      The d'Arsonval mechanism (M), because of its inertia,
537         cannot respond to a frequency greater than 3 Hz, so
538         the pointer responds to the average value of vCC' :

539         VTVM response = 1/T ∫0T |v(t)-Vav|dt

540 mode    write
541 at      2205
542 write   VTVM response = 1/T ∫0T |v(t)-Vav|dt

543            The manufacturer marked this VTVM meter scale to
544         indicate R.M.S. volts when a simple sine wave is
545         applied to the INPUT. Therefore, the VTVM indication is:

546         VTVM indication = 1.11/T ∫0T |v(t)-Vav|dt
```

```
        block 1h,   x05m5e3

unit    x05m5e3
back    x05m5e2
next    x05m5f
at      505
write      In general, the value indicated by the VTVM pointer
        is 1.11 times the average of the fully-rectified
        ripple of the INPUT voltage.  This is mathematically
        expressed by the following previously-mentioned formula:
at      1207
join    x05s5a
***

unit    x05m5f
back    x05m5e
next    x05s5c
calc    n120⇐1
erase
catchup
at      505
write      Let's look at some non-sinusoidal waveforms from
        the Function Generator and see how this applies:

           Accomplish this task:

           On the A channel of the oscilloscope:

        Display two cycles of a square wave with Vpp = 20 V,
        and Vav = 0.

        Set the A PREAMP at +DC.

        Use a generator frequency of 1 kHz.

        Connect the VTVM to measure this same signal, starting
        with the 300 RANGE and reducing the RANGE until you
        display the reading most accurately.
***

unit    x05m5g
base
back    x05m5f
at      310
write   What is the reading on the VTVM ?

                   Vindicated =
at      535
writec  n120,,,,⟨s,v51⟩
goto    n120,x,x,x,x05m5g0
arrow   533
store   v51
```

```
ansv     11.0,1
endarrow

entry    x05m5g0
at       810
write    On the basis of your measurement:
at       1105
write    Vindicated =  _____     Vpp for a symmetrical square wave.
calc     v56⇐v51/20
at       1125
writec   n120,,,,(s,v56)
goto     n120,x,x,x,x05m5g0a
join     x05s4f

entry    x05m5g1
inhibit  erase
back     x05m5f
data     x05s4f
arrow    1119
ansv     v56,10%
no
at       1308
write    Vpp = 20 V.

         Vindicated = (s,v51)

         thus, Vindicated = ?? × Vpp

         Press -NEXT- to clear your answer then...
         ... press -DATA- to re-use the calculator
endarrow

entry    x05m5g0a
calc     n120⇐2
at       1307
write       For a square wave symmetrical about 0 V:

                  Vpp = 2 V0p = 2 Vrms

         therefore your conversion factor is:

            Vrms = V0p =  _____    × the VTVM indication.
at       3204
write    -HELP- is available
help     x05s5f
join     x05s4f

entry    x05m5g2
inhibit  erase
back     x05m5f
data     x05s4f
help     x05s5f
arrow    2025
ansv     .9091,.1
no
at       2210
write    Press -NEXT- to erase your answer,
        then, press -DATA- to re-use the calculator.
endarrow

----------------------------------------------------------- part=1, block=i ---------


        block 1i,  x05m5h


unit      x05m5h
back      x05m5g
next      x05m5h1
erase
catchup
at        1010
write     Now adjust the ± dc level adust on the  func-
          tion generator to produce a sq. wave such that:

          V+pk = 20 volts and V-pk = 0 volts as measured

          on the scope. The frequency is left at 1 kHz.

          NOTE: the dc level adjust interacts with the
          amplitude, therefore, you must adjust them both
          to obtain the desired signal.
at        3007
write                    Press -NEXT- when ready.

unit      x05m5h1
pack      n33,+(ghi)(no)+(cd)(defg)caba<f(tuv)g(ab)>d(defghi)(stu)++++++j
join      ckdw
jump      n47,x,x05m5i
next      x05m5h
***

unit      x05m5i
back      x05m5h
next      x05m5j
at        1010
write     What is the VTVM indication ?

              ______ volts
arrow     1210
ansv      11.0,1
at        1410
write     That's correct! Note that changing Vav
          changes Vrms as well as V0-p , however,
          Vpp and the indication on the VTVM are
          the same.
***

unit      x05m5j
back      x05m5i
at        1010
write     You could therefore conclude that the
```

```
        VTVM indication for a given waveform
        is directly proportional to the
         _     voltage of that waveform.  (A,B,C,D)
at      2110
write   A)   RMS
        B)   AVERAGE
        C)   0-PEAK
        D)   PEAK-PEAK
arrow   1310
answer  (D,d)
***

unit    x05m5k
back    x05m5j
at      210
write   NOTE: Study this sequence carefully. You'll
        be asked a problem based on this method.
at      522
write   Consider this waveform:
at      722
size    2
write      v(t)
size    0
join    x05s5e
gdraw   0,1;2,2;6,0;8,1
pause
at      2018
                         1  T
write              Vav = - ∫  v(t)  dt
                         T  0
pause
hbar    8,1,-
at      1148
write   ÷ Vav = 1
***

unit    x05m5l
back    x05m5k
at      522
write   Performing the operation:

                v(t) - Vav
join    x05s5e
gdraw   0,0;2,1;6,-1;8,0
***

unit    x05m5m
back    x05m5l
at      522
write   Next finding the magnitude:

            | v(t) - Vav |
join    x05s5e
gdraw   0,0;2,1;4,0;6,1;8,0
pause
at      1818
                              1  T
write   calculating:  V1  =   -  ∫ |v(t)-Vav| dt
                              T  0
pause
hbar    8,.5,-
```

```
at      1348
write   ⇐ V1 = .5
pause
at      2118
write   The VTVM should therefore indicate :

        1.11072 × V1   or approximately .555 volts
```

```
----------------------------------------------------------------------- part=1, block=j ---------
```

```
        block 1j,   x05m5n
```

```
unit    x05m5n
term    test
back    x05m5k
at      1010
write   If you would like to repeat the last graphical
        sequence explaining the VTVM response......

        press -BACK-. Otherwise press -NEXT-.
***

unit    x05m5o
back    x05m5n
erase
catchup
at      1010
write   At this time you might want to experiment
        with some waveforms other than the square
        wave from the function generator. See if
        you can predict what they should indicate
        on the VTVM for a given amplitude, then
        verify this by measuring it with the VTVM.


        When you are ready for a challenge to your
        prowess............PRESS -NEXT-.
at      2110
write                       REMEMBER
at      2310
join    x05s5a
***

unit    x05m6a
calc    n120⇐3
next    x05end
back    x05m5o
base
help    x05s6a
at      3210
write   HELP is available........
join    x05s5e
gdraw   0,0.5;2,1.5;4,1.5;4,0.5;6,-.5;8,-.5;8,.5
at      410
```

```
write    On the basis of what you have learned in this
         experiment, what would the VTVM indicate for
         this waveform?  ____    volts
at       1918
join     x05s5a
join     x05s4f

entry    x05m6a1
inhibit  erase
data     x05s4f
help     x05s6a
next     x05end
back     x05m5o
arrow    625
ansv     .833,.01
no
at       718
write    Press -NEXT- to clear you answer then...
         ...press -DATA- to re-use the calculator
***

unit     x05s1a
at       505
write       The RANGE setting indicates the largest rms volt
         signal that the voltmeter can measure.  Thus, if
         you wanted to measure a signal of approximately
         15 rms volts, you would not set the RANGE dial to
         10.0, but rather, to 30.0 to obtain a readable
         indication.
end
***

unit     x05s4a
next     x05m4a1
back     x05m4a
at       510
write    I caught you daydreaming, didn't I !
at       710
write    Come on now, you can do better than that
         I asked for 2000 Hz. In case it slipped your
         mind....

               Freq.out = Freq. setting × Multiplier.

         Let's set it carefully and continue on.
               Press -NEXT- when ready.
***

unit     x05s4b
at       510
write    Surely you're not nervous!
         Let's try that again.

         Just set the range switch to 30  and then ...

         Press -NEXT-.
pause
```

```
pack      n33,+++++++++++++++++++++j
join      ckd
jump      n47,x05s4b,x05m4c

------------------------------------------------------------------ part=1, block=k ---------


     block 1k,   x05s4c


unit      x05s4c
at        510
write     Not bad. You're just a little high.
          In order to get good results we need
          to be a little more precise.

          I want that needle right on 25 VRMS.
          When you've got it, press -NEXT-.
pause
jump      x05m4d1
***

unit      x05s4d
at        510
write     You're just a little low. To get good
          results we must be precise as possible.

          Set the amplitude as close to 25 VRMS
          as you can and then press - NEXT - .
pause
jump      x05m4d1
***

unit      x05s4e
at        610
write     Are you sure that you know all that ?

          The A channel should be
          AC coupled at 100 volts
          full scale. Internally
          trigger the sweep from
          AC levels in the AUTO mode.
          Display only the A channel,
          and sweep it normally (not
          times 5).

          Then, press -NEXT-.
pause
pack      n33,++p++f+ab+++++++++++++
join      ckdw
jump      n47,x,x05m4h
next      x05s4e
***

unit      x05s4f
inhibit erase
```

```
calcs    n120,n121⇒922,1122,1123,2025,625
mode     erase
at       3019
write    Press -NEXT- to enter your answer above
         Press -BACK- to recalculate
at       n121
write    >
mode     write
at       2737
erase    20
at       2838
erase    15
catchup
draw     2617;2657;2957;2917;2617
at       2719
write    CGE Calculator
         Enter Expression:
                                   =
arrow    2837
store    v100
ok
endarrow
at       2938
show     v100
at       3019
write    Press -NEXT- to enter your answer above
         Press -BACK- to recalculate
pause
goto     key=back,x05s4f,x
jump     n120,x05m4i1,x05m4i2,x05m5g1,x05m5g2,x05m6a1
***

unit     x05s5a
write
```

$$V_{\text{indicated}} = \frac{\pi \sqrt{2}}{4} \quad \frac{1}{T} \int_0^T | v(t) - V_{av} | dt$$

$$\text{where } V_{av} = \frac{1}{T} \int_0^T v(t)\ dt.$$

$$\text{Here: } \frac{\pi \sqrt{2}}{4} = \frac{\sqrt{2}\ /\ 2}{2\ /\ \pi} = 1.11 \text{ for a sine.}$$

```
***

unit     x05s5b
origin   1510
axes     0,-100,300,100
scalex   2π
scaley   1
markx    π,π/4
labely   1,.25
---------------------------------------------------------------- part=1, block=1 -----------


        block 11,   x05s5b1
```

```
unit    x05s5b1
at      705
write   and calculate the average of the squared wave as Y₁:
at      2019
write   Y₁ = (1/T) ∫₀ᵀ ( v(t) )² dt =
mode    rewrite
at      1828
write   Plato is computing Y₁ by increments.
calc    v59⇐0
doto    2line,v70⇐1,50
calc    v57⇐(sin(2πv70/50))²
        v58⇐(sin(2π(v70-1)/50))²
        v59⇐v59+(v57+v58)/100
        v71⇐πv70/25
gdraw   v71,0;v71,v57
at      2044
showt   v59
2line
mode    erase
at      1828
write   Plato is computing Y₁ by increments.
mode    write
hbar    2π,.5,-
graph   2.1π,.5,Y₁
end
***

unit    x05s5c
pack    n33,000000000000a00b0+++++b+000ab0
join    ckcw
jump    n47,x,x05s5d
next    x05m5f
***

unit    x05s5d
pack    n33,+(ghi)(nop)+(cd)(defg)(bc)eba<f(tuv)g(ab)>d(efghi)(abcd)++++++j
join    ckdw
jump    n47,x,x05m5g
next    x05m5f
***

unit    x05s5e
origin  1515
axes    0,-128,256,128
scalex  8
scaley  2
markx   4,1
labely  1,.25
at      1730
write   T/2
at      1747
write   T
***

unit    x05s5e2
at      117
write   HP 400D VACUUM TUBE VOLTMETER
```

```
982  draw    117;146
983  at      1413
984  write   Internal Schematic Diagram of the VTVM
985  draw    1413;1451
986  at      70,431
987  write    +

988          v(t)

989           -
990  draw    88,448;138,448;skip;138,453;138,443
991  circle  7,150,448,135,225
992  draw    143,448;193,448;193,428;197,424;189,416;197,408
993          189,400;197,392;193,388;193,368;88,368;skip;193,448;293,448;skip;193,368;293,368
994  draw    293,448;276,431;skip;271,426;254,409;271,392
995          skip;276,387;295,368;314,387;skip;319,392
996          336,409;319,426;skip;314,431;297,448
997  draw    276,431;276,424;269,431;276,431;skip;280,427
998          272,435
999  draw    276,387;276,394;269,387;276,387;skip;280,391
1000         272,383
1001 draw    319,391;319,384;312,391;319,391;skip;315,395
1002         323,387;skip;319,426;319,433;312,426;319,426
1003         skip;323,430;315,422
1004 draw    254,409;254,374
1005 circle  6,254,368,90,270
1006 draw    254,361;254,329;280,329
1007 circle  15,295,329
1008 draw    309,329;336,329;336,409
1009 at      85,456
1010 write   A
1011         ◆
1012 at      85,360
1013 write   ◆
1014         A'
1015 at      190,440
1016 write   ◆
1017 at      190,360
1018 write   ◆
1019 at      292,440
1020 write   ◆
1021 at      251,401
1022 write   ◆
1023 at      333,401
1024 write   ◆
1025 at      292,360
1026 write   ◆
1027 at      251,321
1028 write   ◆
1029 at      333,321
1030 write   ◆
1031 end

 ---------------------------------------------------------------- part=1, block=m ----------
```

```
      block 1m,  x05s5f

unit     x05s5f
erase
catchup
at       811
write    Vpp = 2 V0p = 2 Vrms

         Vindicated =  (s,v51)      × Vpp
                        20

         Vpp =       20     × Vindicated
                   (s,v51)

         thus, Vrms =  Vpp   =   20            × Vindicated
                        2      (s,v51) × 2
pause
jump     x05m5g
***

unit     x05s6a
back     x05m6a
erase
catchup
join     x05s5e
gdraw    0,0.5;2,1.5;4,1.5;4,0.5;6,-0.5;8,-0.5;8,0.5
hbar     8.25,.5,-
at       525
write    Vav = ∫_0^T v(t) dt
locate   8.5,.4
write    ← Vav = 1/2
***

unit     x05s6b
back     x05s6a
at       525
write    Performing the operation:
              v(t) - Vav
join     x05s5e
gdraw    0,0;2,1;4,1;4,0;6,-1;8,-1;8,0
***

unit     x05s6c
back     x05s6b
at       522
write    Next, finding the magnitude
            | v(t) - Vav |
join     x05s5e
gdraw    0,0;2,1;4,1;4,0;6,1;8,1;8,0
***

unit     x05s6d
back     x05s6c
help     x05s6e
next     x05m6a
join     x05s5e
```

```
gdraw   0,0;2,1;4,1;4,0;6,1:8,1;8,0
at      321
write   Recalling the formula:

                        π√2       1   T
        V           =  -----      - ∫  |v(t)-V  |dt
         indicated       4        T 0          av
              π√2
        where ----- = 1.11
                4
at      2005
write      Note that the area to the left of t=T/2 is identical
        to the area to the right.

           Thus, you only need to integrate from t = 0 to
        t = T/2 and multiply by two.

           Press -NEXT- to enter your answer.

           Press -HELP- for further assistance.
***

unit    x05s6e
back    x05s6d
next    x05s6f
help    x05s6g
at      709
write      To find the area under the curve |v(t)-V  |:
                                                   av

        Press -NEXT- for a geometric approach.

        Press -HELP- to solve the integral directly.
***

unit    x05s6f
help    x05s6g
back    x05s6a
next    x05m6a
join    x05s5e
gdraw   0,0;2,1;4,1;4,0;6,1;8,1;8,0
at      208
write   Note that the figure to the left of t=T/2 is:

        (rectangle of area 1/2)
doto    3line,n101⇐1,8,1
calc    v102⇐n101 × 0.25
calc    v103⇐n101 × 0.125
hbar    v102,v103,-
3line
at      432
write   - (shaded triangle 1 × 1 × 1)
                           -   -
                           2   4
at      622
write   = 1 - 1 = 3
          -   -   -
          2   8   8
at      1924
write   Recall that the total area is twice
        as large ( = 2 × 3/8 = 3/4)

        and V           = 1.11072 × 3/4
             indicated
write   {at,2608}Press -NEXT- to enter your answer
```

```
                                  -BACK- to review this sequence

                                  -HELP- to see the integral approach
------------------------------------------------------------- part=1, block=


        block in,  x05end


unit     x05s6g
help     x05s6f
back     x05s6a
next     x05m6a
join     x05s5e
gdraw    0,0;2,1;4,1;4,0;6,1;8,1;8,0  .
at       321
write    V_indicated = π√2/4  1/T ∫_0^T |v(t) -V_av|dt
pause
at       621
write    = 1.11072 × 1/T × 2 × ∫_0^T/4 4/T tdt + ∫_T/4^T/2 dt
at       541
write    [                        ]

pause
at       921
write    = 1.11072 × 1/T × 2 ×  4/T t²/2|^T/4 + ( T/2 - T/4 )
at       841
write    [                        ]

pause
at       2021
write    = 1.11072 × [ 2 ×          ]
calc     v61⇐-.1
zero     v62
mode     rewrite
at       1821
write    Plato Computing Integral
doto     1line,v60⇐0,20
calcs    v60-11,v61⇐v61+0.1,1
gdraw    0.2×v60,0;0.2×v60,v61
gdraw    (0.2×v60)+4,0; (0.2×v60)+4,v61
calcc    v60-11,v63⇐0.0125×v60×v61,v62⇐v63+(0.025×v60×v61)-0.25
at       2038
writec   v60-11,‹t,v63›,‹t,v62›
1line
at       1821
write
mode     write
at       2608
write    Press -NEXT- to enter your answer

               -BACK- to review this sequence

               -HELP- for the geometrical approach.
***
```

```
1172  unit    x05end
1173  back    x05m6a
1174  join    imode
1175  jump    n47,x05end,x
1176  course  n2
1177  calcc   n2='ee244',
1178          nc(n21+1)⇐(nc(n21+1)$mask$o77777777770000000000)+o4603000000,;
1179          nc(n21+1)⇐nc(m21+1)
1180  erase
1181  output  /// student has completed experiment ///
1182  join    endunit
1183  join    jmpmes
1184  jumpout cgeindex,quest1

1185  entry   leave
1186  end     lesson
1187  ***

1188  unit    endunit
1189  course  n2
1190  jump    n2≠'ee244',leave,x
1191  calc    nc(n21+7)⇐nc(n21+7)+ahelp
1192          vc(n21+6)⇐vc(n21+6)+atime/60000
1193  ***Incl.cge s.r. & terms sample,index,imode,comment,slides.
1194  use     eex00,ck1
1195  use     ck2
1196  use     ck3
1197  use     ck4
1198  use     ck5
1199  use     ck6
      ckcw          not found               226     307     957
      ckd           not found               201     212     240     296     838
      ckdw          not found                77     659     878     963
      ckd1          not found               243     246
      endunit   x05end         1188          22    1182
      imode         not found                34     184     446    1174
      jmpmes        not found              1183
      leave     x05end         1185        1190
      x05end    x05end         1172         775     794    1175
      x05m0a    eex05id          30          35      52
      x05m1a    x05m1a           51          33      66
      x05m1b    x05m1a           65          53      79      82
      x05m1b1   x05m1a           74          67
      x05m2a    x05m1a           81          78      96
      x05m2b    x05m1a           95          83     118
      x05m2c    x05m1a          117          97     125
      x05m2d    x05m2d          124         119     153
      x05m3a    x05m2d          152         126     198
      x05m4a    x05m2d          181         154     185     210     815
      x05m4a1   x05m2d          199         814
      x05m4b    x05m2d          204         202     224
      x05m4c    x05m4c          215         213     228     231     839
      x05m4d    x05m4c          230         227     258
      x05m4d1   x05m4c          238         232     255     850     860
      x05m4e    x05m4c          257         241     268     313     330     351
      x05m4f    x05m4c          267         259     287
```

```
x05m4g        x05m4c           286                 269
x05m4h        x05m4h           299                 297     309     879
x05m4i        x05m4h           311                 308     368
x05m4i1       x05m4h           327                 913
x05m4i2       x05m4h           348                 913
x05m5a        x05m4h           366                 314     383     419
x05m5b        x05m4h           382                 369     407
x05m5c        x05m5c           406                 384
x05m5d        x05m5c           418                 408     444
x05m5e        x05m5c           442                 420     447     458         560
x05m5e1       x05m5c           457                 445     472
x05m5e2       x05m5e2          471                 459     549
x05m5e3       x05m5e3          548                 473
x05m5f        x05m5e3          559                 550     580     603         631   965   959
x05m5g        x05m5e3          578                 643     964    1045
x05m5g0       x05m5e3          591                 586
x05m5g0a      x05m5e3          618                 599
x05m5g1       x05m5e3          601                 913
x05m5g2       x05m5e3          629                 913
x05m5h        x05m5h           642                 661     664
x05m5h1       x05m5h           657                 644
x05m5i        x05m5h           663                 660     679
x05m5j        x05m5h           678                 665     694
x05m5k        x05m5h           693                 715     746
x05m5l        x05m5h           714                 724
x05m5m        x05m5h           723
x05m5n        x05m5n           744                 754
x05m5o        x05m5n           753                 776     795
x05m6a        x05m5n           773                1048    1078    1105        1131          1173
x05m6a1       x05m5n           790                 913
x05s1a        x05m5n           803                  68      75     127
x05s4a        x05m5n           813                 202
x05s4b        x05m5n           828                 213     839
x05s4c        x05s4c           841                 244
x05s4d        x05s4c           852                 247
x05s4e        x05s4c           862                 297     880
x05s4f        x05s4c           882                 326     329     347   604   350   628   600
                                                   632     789     792         912
x05s5a        x05s4c           915                 455     557     771         788
x05s5b        x05s4c           921                 378     388     429
x05s5b1       x05s5b1          929                 392
x05s5c        x05s5b1          955                 561
x05s5d        x05s5b1          961                 958
x05s5e        x05s5b1          967                 704     720     729  1064   781  1072  1051
                                                  1079    1106    1132
x05s5e2       x05s5b1          979                 474
x05s5f        x05s5f          1033                 627     633
x05s6a        x05s5f          1047                 778     793    1060        1104          1130
x05s6b        x05s5f          1059                1068
x05s6c        x05s5f          1067                1076
x05s6d        x05s5f          1075                1094
x05s6e        x05s5f          1093                1077
x05s6f        x05s5f          1102                1095    1129
x05s6g        x05end          1128                1096    1103
ahelp                         1191
atime                         1192
back                           198       210       224     912
```

```
key             198     210     224     912
nc             1178    1176    1179    1179    1191         1191
n101           1111    1112    1113
n120            315     344     562     585     586  619   598  774   599
                884     913
n121            884     889
n2             1176    1177    1189    1190
n21            1178    1178    1179    1179    1191        1191 1192  1192
n33              76     200     211     225     239  295   242  306   245
                658     837     877     956     962
n47              35      78     185     202     213  244   227  247   241
                297     308     447     660     839  964   879 1175   958
sin             380     390     939     940
sqrt            394
vc             1192    1192
v100            903     907
v102           1112    1114
v103           1113    1114
v51             585     588     596     611    1038        1041       1043
v55             319     322     337     353     380         380  390   390
v56             322     332     596     598     606
v57             939     941     943
v58             940     941
v59             394     937     941     941     945
v60             394     396    1156    1157    1158 1159  1158 1160  1159
               1160    1160    1162
v61            1151    1157    1157    1158    1159        1160       1160
v62            1152    1160    1162
v63            1160    1160    1162
v70             938     940
v71             942     943     943
%               332     353     606
Vrms          398
Y1 >            952
-               397     710     735     951    1053        1114
π               397     398     430     431     432  926   433  926   924
                940     951     952
πv70            939     942

                        lesson information

      lesson name = eex05

      starting date = 06/01/73

      last edited on 08/21/74 at 11.23.41

                  by neal of course eecge

                  at site 7, station 27

      author name = J. P. Neal

      department = EE

      telephone number = 333-4351
```

discipline = EE

grade level = Freshman

descripion of lesson = The Operation and Uses of the Vacuum Tube Voltmeter, HP 400D.

```
                         lesson eex06 at 2:43 am on tuesday, august 27, 1974
-------------------------------------------------------------- part=1, block=a ----------


      block 1a,  eex06id

stop
****     For Neal, CGERL, Room 248, EEB.

One line description of this lesson --

   Measurements of Transients.

          Divisions of this Lesson:        Block    Unit

        Id for this file                   eex06id
        Experiment eex06;
          Objectives                       x06m0a   x06m0a
          Measure transient waveshapes     x06m0a   x06m1a
          Measure and calc. time const.    x06m1q0  x06m2a

        Final edit 21 aug 74 neal.

*list   info
*list   symbols
*list   varian,charset,cgeindex,cgechar
****
start
finish  endunit
write   ‹at,1010› Loading the CGE Character Set
charset cgeindex,cgechar
erase
dataon.
area    eex06
ext     0
calc    n99⇐1               $$ used for restart skipping
-------------------------------------------------------------- part=1, block=b ----------


      block 1b,  x06m0a

unit    x06m0a
restart
join    imode
jump    n47,x06m0a,x
next    x06m0b
calc    n99⇐0
at      407
write              MEASUREMENTS OF TRANSIENTS

              This is an experimental study of transients in a
        series circuit which contains resistors and a single
        energy-storage element, such as a capacitor or an
        inductor.

           The principal objectives of this experiment are:

        1. To measure and compare the waveshapes of the input
        and element voltages, currents, powers, and energies
        in a series RC circuit, when the source voltage is
        constant.

        2. To measure the time constant of the current of a
        series RC circuit and compare it with the value
        calculated from the nominal parameters of the circuit
        devices.
***

unit    x06m0b
back    x06m0a
next    x06m1a
at      707
write      A square-wave voltage is constant during each
        half-period.  Consequently, when a square-wave
        voltage drives a series RC or RL circuit, the
        circuit's response to a constant voltage can be
        studied by examining its response to the square-
        wave voltage during any half-period.  Furthermore,
        being repetitive, the input and element voltages
        can be displayed on the Scope.
pause
at      1907
write      Hence, the response of an RC circuit to a constant
        voltage applied when the capacitor is INITIALLY
        DISCHARGED can be studied experimentally by driving
        the RC circuit with a square-wave voltage having a
        zero value during each alternate half-period, and
        a frequency sufficiently low for the transients to
        decay practically to zero during each half-period.
***

unit    x06m1a
back    x06m0b
next    x06m1a1
help    x06s1a
at      707
write      Display one period of the adjustable SQUARE OUTPUT
        of the Function Generator on channel A of the Scope.

           Trigger the Scope from the Function Generator.

           Accurately adjust the open-circuit SQUARE-wave
        OUTPUT of the Function Generator to:

           Vmax = 20 V,  Vmin = 0,  and  f = 1000 Hz.

        Use A VOLTS FULL SCALE at 20 V for greatest accuracy,
        and lower the zero volts base line of the display
```

```
            to the bottom line, 5 cm below the center of the
            CRT screen.

               Disregard any small peak at the start of the trace.

               Recall that the possible error with the Scope is
            ± 3 % of the VOLTS FULL SCALE setting, so you should
            avoid introducing further errors due to inaccuracies
            in your settings, readings, or calculations.
------------------------------------------------------------ part=1, block=c ----------


         block 1c,  x06m1a1

   unit     x06m1a1
   pack     n33,000000000000a00b0c0000bc000a00
   join     ckcw
   next     n47,x06m1a,x
   jump     n47,x,x06m1a2
   ***

   unit     x06m1a2
   pack     n33,+gne(cd) (de)caba<f(rstuv)g(ab)>d(ef) (tu)+aaa++1
   join     ckdw
   next     n47,x06m1a,x
   jump     n47,x,x06m1b
   ***

   unit     x06m1b
   at       1007
   write       The Scope is the most accurate of the rack-
            mounted instruments.  Consequently, please readjust
            the frequency of the Function Generator, so the
            swept length of one period, as observed on the Scope,
            is exactly 10 cm, for the period of 1 ms and the
            frequency of 1000 Hz.
   ***

   unit     x06m1b1
   pack     n33,000000000000a00b0c0000bc000a00
   join     ckcw
   next     n47,x06m1a,x
   jump     n47,x,x06m1b2
   ***

   unit     x06m1b2
   pack     n33,+gne(cd) (de)caba<f(stu)g(ab)>d(ef) (tu)+aaa++1
   join     ckdw
   next     n47,x06m1a,x
   jump     n47,x,x06m1c
   ***

   unit     x06m1c
   back     x06m1a
```

```
next    x06m1d
jump    n99,x,x,x06m1i1,x06m1q0a $$ units added for retarts
at      807
write      DO NOT readjust any dial or knob on the Function
        Generator during the remainder of this task.  You
        have correctly set the open-circuit voltage vg of the
        Function Generator and it will automatically try
        to maintain the terminal voltage constant.

           However, the terminal voltage will still vary with the
        load current, as was observed in a previous experiment
        where it was found that the Function Generator with
        the controls at a fixed setting could be approximately
        represented theoretically by an ideal voltage source
        vg in series with an internal resistance Rg.
***

unit    x06m1d
back    x06m1c
next    x06m1d1
help    x06s1a
at      707
write      Connect the sensor cable of the RC BOARD, ITEM 33,
        to the CGE Interface.

           Ground Terminal 4 of the RC BOARD.

           Drive Terminal 1 of the series resistor-capacitor
        circuit with the adjusted SQUARE-wave OUTPUT of the
        Function Generator. Note how the display of vin changes !

           Observe the input voltage vin on channel A with
        A VOLTS FULL SCALE at 50 V, and observe the input
        current i on channel B with B VOLTS FULL SCALE at
        2 V.  Return the zero base line to the center of
        the screen.


                 -HELP- is available.
***

unit    x06m1d1
pack    n33,a0bc00000000c00abd0000ad000c00
join    ckcw
next    n47,x06m1d,x
jump    n47,x,x06m1d2
***

unit    x06m1d2
pack    n33,kgoc(od)(de)cdba<f(stu)g(ab)>d(ef)(tu)+aaa++1
join    ckdw
next    n47,x06m1d,x
jump    n47,x,x06m1e

---------------------------------------------------------------- part=1, block=d -----------
```

block 1d, x06m1e

```
unit     x06m1e
base
back     x06m1d
next     x06m1f
define   x⇐n120
         y⇐n121
         xmax⇐n122
         ymax⇐n123
calc     x⇐398
         y⇐425
         ymax⇐20
         xmax⇐10
join     x06s1b
gdraw    -10,0;-10,16;0,16;0,0;10,0
graph    2,20,vg(t)
at       661
write    t
at       405
write       The voltage source of the
         RC circuit is a square wave
         having:


                   Vmax =          volt.

                   Vmin =          volt.
arrow    818
long     2
answer   20
no
at       1205
write       If you have not change the Function Generator
         controls, Vmax of vg should be 20 volt.  The Scope
         is displaying the input voltage of the RC circuit.

            The source voltage is theoretically internal to
         Function Generator and cannot be displayed under load.
arrow    1018
answer   0
long     1
inhibit erase
no
at       1205
write       If you have not changed the generator controls,
         Vmin of vg should be 0 volt.
endarrow
***

unit     x06m1f
back     x06m1e
next     x06m1g
calc     y⇐255
join     x06s1b
```

```
calc    n95⇐1
doto    06m1f1,n94⇐-10,5,10
gdraw   n94,0;n94,n95(20)
graph   2,20,i(t)
at      1561
write   t
funct   n95(20)exp(-.5(v100-n94)),v100⇐n94,n94+10,.5
calc    n95⇐n95×-1
06m1f1
at      1305
write      Without changing any
        connections, turn the A PRE AMP
        to OFF and by adjusting the
        A*B SEPARATION knob, use the
        undeflected channel A trace
        for a zero baseline of the
        current display.
pause
mode    erase
at      1305
write      Without changing any
        connections, turn the A PRE AMP
        to OFF and by adjusting the
        A*B SEPARATION knob, use the
        undeflected channel A trace
        for a zero baseline of the
        current display.
inhibit erase
jump    x06m1f1
***

unit    x06m1f1
pack    n33,a0bc00000000c00abd0000ad000c00
join    ckc
inhibit erase
jump    n47,x06s1c,x06m1f2
***

unit    x06m1f2
pack    n33,kgoc(cd)(de)edba<f(rstu)g(ab)>d(ef)(tu)+aaa++1
join    ckd
inhibit erase
jump    n47,x06s1c,x06m1g

------------------------------------------------------------------------------- part=1, block=e -----------


     block 1e,  x06m1g


unit    x06m1g
back    x06m1e
next    x06m1h
at      1305
write      The exponential current
        of the RC circuit, read
```

```
               experimentally has:

                         Imax =              mA

                         Imin =              mA .
arrow     1718
ansv      8.4,1
no
at        2205
write       You can read the amplitude
          more accurately by momentarily
          going to a smaller FULL SCALE
          setting on B VOLTS.
arrow     1918
ansv      -8.0,1
inhibit erase
no
at        2205
write       You can read the amplitude
          more accurately by momentarily
          going to a smaller FULL SCALE
          setting on B VOLTS.
endarrow
inhibit erase
***

unit      x06m1h
back      x06m1e
next      x06m1h1
calc      y⇐85
          ymax⇐200
join      x06s1b
graph     2,200,ps(t)
graph     10,-20,t
doto      06m1h1,n94⇐-10,-2,10
gdraw     n94,0;n94,20(8.8)
funct     20(8.8)exp(-1(v100-n94)),v100⇐n94,n94+10,.5
06m1h1
at        2505
write       The power delivered by the
          source can be calculated
          by simply multiplying the
          source voltage (20 or 0 V) by
          the current for each point in
          time.
***

unit      x06m1h1
next      x06m1h1
at        1007
write       Now, in order to read i(t) versus t more accurately
          for the next tabulation, please set the Scope TIME
          at 500 μs and B VOLTS  at 1 V.
            Turn the A PRE-AMP to +DC.
pause
pack      n33,a0bc00000000c00abcd0000ad000c00
join      ckow
```

```
jump     n47,x,x06m1h2
***

unit     x06m1h2
next     x06m1h1
pack     n33,j foc(cd) (de) (cd) dba<f(rtu)g(ab)>d(ef) (tu) +aaa++1
join     ckdw
jump     n47,x,x06m1i
--------------------------------------------------------------- part=1, block=f -----------


      block 1f,  x06m1i

unit     x06m1i
base
help     x06s1f
back     x06m1e
at       207
write       Enter the values of the source voltage vg, and
         measure on the Scope display and enter the values of
         of the circuit current i, in the table below.  As you
         properly enter each pair of values, I will then
         calculate and enter pg = vgxi within 6 %.

                  t            vg            i           pg

                 (ms)          (V)          (mA)        (mW)

                 0.02

                 0.1+

                 0.2+

                 0.3+

                 0.4+

                 0.5+

                 0.6+

                 0.7+

                 0.8+

                 0.9+

                             Help is available
goto      key=back,replot,x
calc      n100⇐1224
          n1⇐104
          v101⇐20
          v102⇐8.4
```

```
join    x06s1d
calc    v102⇐3.3
join    x06s1d
calc    v102⇐1.2
join    x06s1d
calc    v102⇐.5
join    x06s1d
calc    v102⇐.2
join    x06s1d
calc    v102⇐-7.6
        v101⇐0
join    x06s1d
calc    v102⇐-3.6
join    x06s1d
calc    v102⇐-1.2
join    x06s1d
calc    v102⇐-.5
join    x06s1d
calc    v102⇐-.2
join    x06s1d
pause

entry   replot
next    x06m1i0
jump    key=back,x,x06m1i0
at      1223
write        20          <s,v80>       <s,v105>

             20          <s,v81>       <s,v106>

             20          <s,v82>       <s,v107>

             20          <s,v83>       <s,v108>

             20          <s,v84>       <s,v109>

             0           <s,v85>       0

             0           <s,v86>       0

             0           <s,v87>       0

             0           <s,v88>       0

             0           <s,v89>       0
***

unit    x06m1i0          $$ this is a dummy unit for restart
restart
jump    n99,x,x,x06m1a

entry   x06m1i1
zero    n99
jump    x06m1j
***

unit    x06m1j
```

```
back     x06m1i
next     x06m1k
at       807
write       The input power p_g, calculated above,
         will be plotted versus time t, when you press -NEXT-.
calc     y_max⇐200
         x_max⇐10
         x⇐248
         y⇐160
pause

entry    power
join     x06s1b
gdraw    -10,0;-10,v105;-8,v106;-6,v107;-4,v108;-2,v109;0,0
graph    2,200,p_g(t)
graph    10,-20,t
exit
calc     n149⇐104
doto     06m1j1,n150⇐1,5,1
graph    -12+2(n150),v(n149+n150),◆
06m1j1
doto     06m1j2,n150⇐1,6,1
graph    2(n150-1),0,◆
06m1j2

----------------------------------------------------------- part=1, block=g -----------


      block 1g,  x06m1k


unit     x06m1k
base
term     work
back     x06m1i
next     x06m1l
at       405
write       The energy w_g(t) supplied to the circuit by the
         voltage source v_g is

                        w_g(t) = ∫_0^t p_g(t) dt.


            When you press -DATA-, I will calculate and
         plot w_g(t) versus t for one period, using your data.

calc     y_max⇐50
         x⇐248
         y⇐160
         x_max⇐10
pause

entry    work
join     x06s1b
graph    2,50,w_g(t)
graph    10,-5,t
```

```
calc     n111⇐104
         v112⇐v134⇐0
         n130⇐1
         n132⇐-10

entry    x06m1k1
calc     v131⇐(v(n111+n130)-v(n111+n130+1))/4
doto     06m1k2,v140⇐.25,1,.25
calc     v133⇐v(n111+n130+1)+(1-v140+.25)4(v131)
calc     v112⇐v112+.025v133
gdraw    2(v140-.25)+n132,v134;2(v140)+n132,v112
calc     v134⇐v112
06m1k2
calc     n130⇐n130+1
         n132⇐n132+2
goto     n132≤-2,x06m1k1,x
gdraw    0,v112;10,v112
exit
at       2912
write    w_g(t) = ∫_0^T p_g(t) dt. =<z,v112> µJ (within 9%)
***

unit     x06m11
base
term     resis
back     x06m1k
next     x06m1m
at       305
write       While the energy was being supplied to the RC
         circuit by the source, energy was being dissipated in
         the resistances of the circuit. The total resistance
         of the RC circuit includes the generator internal
         resistance well as the resistances of the various
         circuit elements on the RC BOARD. Hence, in the
         equivalent circuit below:

                          R = R_g + R_1 + R_2

draw     2023;2030;1931;2133;1935;2036;2044;2344;skip
         2341;2347;skip;344,136;2444;2744;2723;2523
circle   36,343,101,132,48
draw     2523;176,122
draw     176,149;2023
circle   14,176,136
at       1933
write    R
at       2449
write    C
at       2229
write    i  →
draw     235,164;271,164
at       2318
write    +
         v_g
         -
pause
at       1305
```

```
write       As you may verify, the manufacturer's rated
         equivalent resistance values for the Function
         Generator and the circuit board resistors give
         R = 200 + 2000 + 100 = 2300 ohms.

--------------------------------------------------------------- part=1, block=h ----------


      block 1h,  x05m1m


unit     x06m1m
back     x06m1l
next     x06m1n
at       507
write       Let's check this with your experimental
         measurements.

            As we mentioned previously, the
         capacitor voltage is zero when v_g jumps from 0 to
         20 volts at the beginning of each period. Therefore,
         at that instant the only opposition to the flow of
         current is the resistance voltage v_R = iR.  Using
         this relation and your previously-measured current
         in milliamperes:

            R = 20/(.001× ⟨s,v80⟩) = ⟨s,20/(v80×.001)⟩  ohms  (within 6%)
            When you press -NEXT-, I will use your value of R
         with the values you read for i to calculate and
         display the power dissipation p_R = i^2R versus t.
pause
erase
at       210
write       An estimate of the power being dissipated at any
         instant t in the circuit resistance R is

                          p_R(t) = i^2(t) R
calc     y⇐350
         x⇐248
         y_max⇐200
         x_max⇐10

entry    resisp
join     x06s1b
graph    1.5,200,p_r(t)
graph    10,-20,t
calc     v1⇐20/v80
gdraw    -10,0;-10,v1(v80)^2;-8,v1(v81)^2;-6,v1(v82)^2;-4,v1(v83)^2;-2,v1(v84)^2;0,0
gdraw    0,0;0,v1(v85)^2;2,v1(v86)^2;4,v1(v87)^2;6,v1(v88)^2;8,v1(v89)^2;10,0
exit
pause
at       1610
write       An estimate of the energy w_R(t) dissipated in R
         during the interval t = 0 to t = t is

                      w_R(t) = ∫_0^t p_R(t) dt.
```

```
calc     y⇐115
         ymax⇐50

entry    resisw
join     x06s1b
graph    1.5,50,wr(t)
graph    10,-5,t
calc     n111⇐79
         v112⇐v134⇐0
         n130⇐1
         n132⇐-10

entry    x06m1m1
calc     v131⇐(v(n111+n130)-v(n111+n130+1))/4
doto     06m1m2,v140⇐.25,1,.25
calc     v133⇐v(n111+n130+1)+(1-v140+.25)4(v131)
calc     v112⇐v112+.025(v133)²v1
gdraw    2(v140-.25)+n132,v134;2(v140)+n132,v112
calc     v134⇐v112
06m1m2
calc     n130⇐n130+1
         n132⇐n132+2
goto     n132≤-4,x06m1m1,x
gdraw    -2,v112;0,v112
calc     n111⇐84
         n130⇐1
         n132⇐0

entry    x06m1m3
calc     v131⇐(v(n111+n130)-v(n111+n130+1))/4
doto     06m1m4,v140⇐.25,1,.25
calc     v133⇐v(n111+n130+1)+(1-v140+.25)4(v131)
calc     v112⇐v112+.025(v133)²2.353
gdraw    2(v140-.25)+n132,v134;2(v140)+n132,v112
calc     v134⇐v112
06m1m4
calc     n130⇐n130+1
         n132⇐n132+2
goto     n132≤6,x06m1m3,x
gdraw    8,v112;10,v112
exit
at       3112
write    wr(t) = ∫0T pr(t) dt. =⟨z,v112⟩ μJ
---------------------------------------------------------------- part=1, block=i --------


      block ii,  x06m1n

unit     x06m1n
base
back     x06m1m
next     x06m1n1
at       705
write       Let's examine the voltage across the capacitor
```

```
          in the experimental RC circuit, and relate it to the
          current i.

             For this purpose, please return the Scope TIME to
          1 ms, B VOLTS to 2 V, and A VOLTS to 50 V, and
          raise the base line to the center of the screen.

             Since v34 across the current-sensing resistor is
          insignificant in comparison, v24 is like vC.

             Therefore, monitor Terminal 2 on the A channel to
          display vC(t).
***

unit      x06m1n1
next      x06m1n
pack      n33,aebc00000000c00ebd0000ad000c00
do        ckcw
jump      n47,x,x06m1n2
***

unit      x06m1n2
next      x06m1n
pack      n33,kgoc(cd) (de) (cd) dba<f(rtu)g(ab)>d(ef) (tu)+aaa++1
do        ckdw
jump      n47,x,x06m1o
***

unit      x06m1o
back      x06m1n
next      x06m1p
jump      n99,x,x,x,x06m1q0
calc      x⇐356
          y⇐425
          ymax⇐20
          xmax⇐10
join      x06s1b
graph     8,20,vC(t)
graph     10,-2,t
calc      n95⇐1
doto      1lasta,n94⇐-10,5,10
funct     n95(20-20exp(-.5(v100-n94)))+(n95-1)^2(20exp(-.5(v100-n94))),v100⇐n94,n94+10,.5
calcc     n95=1,n95⇐0,n95⇐1
1lasta
at        505
write        The voltage vC across the
          capacitor is exponentially
          increasing towards 20 when
          vg = 20, and is exponentially
          decreasing towards 0 when vg = 0.
***

unit      x06m1p
back      x06m1o
term      try
next      x06m1q0
at        105
```

```
640  write      For this analysis, please read from the Scope and
641             properly enter each value of vC(t), I will then
642             calculate and enter pC = vC×i.

643                   t            vC           i          pC

644                 (ms)          (V)         (mA)        (mW)

645                 0.0-

646                 0.1-

647                 0.2-

648                 0.3-

649                 0.4-

650                 0.5-

651                 0.6-

652                 0.7-

653                 0.8-

654                 0.9-
655  goto       key=back,replotv,x
656  calc       n100÷922
657             n1÷80
658             v102÷0
659  join       x06s1e
660  calc       v102÷12
661  join       x06s1e
662  calc       v102÷16
663  join       x06s1e
664  calc       v102÷18
665  join       x06s1e
666  calc       v102÷19
667  join       x06s1e
668  calc       v102÷20
669  join       x06s1e
670  calc       v102÷8
671  join       x06s1e
672  calc       v102÷3
673  join       x06s1e
674  calc       v102÷1.8
675  join       x06s1e
676  calc       v102÷.4
677  join       x06s1e
678  pause

679  entry      replotv
680  next       x06m1q0
681  jump       key=back,x,x06m1q0
682  calc       n100÷922
683             n1÷80
```

```
doto     1plot,n150⇐0,9,1
at       n100+2
show     v(n1+n150-30)
at       n100+10
show     v(n1+n150)
at       n100+21
show     v(n1+n150-20)
calc     n100⇐n100+200
1plot
```

--- part=1, block=j ----------

block 1j, x06m1q0

```
unit     x06m1q0
restart
calcc    n99=1,n99⇐2,n99⇐0
jump     n99,x,x,x,x06m1a

entry    x06m1q0a
jump     n99,x,x,x,x06m1n
jump     x06m1q
***

unit     x06m1q
next     x06m2a
at       505
write       At any instant, pg(t) = pR(t) + pC(t).

            Over any period 0 < t < T:
         wg(t) = wR(t) + wC(t).

            Graphs of pC(t), wC(t), pG(t), wG(t), pR(t), and
         wR(t) will be shown when you press -NEXT-.
pause
erase
calc     y⇐85
         x⇐120
         xmax⇐10
         ymax⇐200
join     x06s1b
graph    1.5,200,pC(t)
graph    10,-20,t
gdraw    -10,0;-10,v60;-8,v61;-6,v62;-4,v63;-2;v64;0,0;0,v65;2,v66;4,v67;6,v68;8,v69;10,0
calc     y⇐85
         x⇐398
         ymax⇐50
join     x06s1b
graph    1.5,50,wC(t)
graph    10,-5,t
calc     n111⇐60
         v112⇐v134⇐0
         n130⇐1
         n132⇐-8
```

```
calc      v131⇐(v(60)-v(61))/4
doto      06m1q1a,v140⇐.25,1,.25
calc      v133⇐v(61)+(1-v140)4(v131)
calc      v112⇐v112+.025v133
gdraw     2(v140-.25)-10,v134;2(v140)-10,v112
calc      v134⇐v112
06m1q1a

entry     x06m1q1
calc      v131⇐(v(n111+n130)-v(n111+n130+1))/4
doto      06m1q2,v140⇐.25,1,.25
calc      v133⇐v(n111+n130+1)+(1-v140+.25)4(v131)
calc      v112⇐v112+.025v133
gdraw     2(v140-.25)+n132,v134;2(v140)+n132,v112
calc      v134⇐v112
06m1q2
calc      n130⇐n130+1
          n132⇐n132+2
goto      n132≤8,x06m1q1,x
gdraw     0,v112;10,v112

entry     x06m1q3
calc      x⇐120
          y⇐255
          ymax⇐200
join      resisp
calc      x⇐398
          ymax⇐50
join      resisw
calc      x⇐120
          ymax⇐200
          y⇐425
join      power
calc      ymax⇐50
          x⇐398
join      work

unit      x06m2a
back      x06m1p
next      x06m2b
at        507
write        Transients occur whenever a stable system is
          disturbed, so it behooves us to relate the wave-
          shapes you have just observed to the values of R
          and C in the equivalent circuit.

             As with any dissipative system containing a single
          type of storage element, the differential equation
          which applies during any half-period in which the
          source voltage vg is constant is
                                      1  t
                   vg(t) = R i(t) +  -  ∫   i(t) dt + VC0
                                      C  0

          where VC0 is the capacitance voltage at t = 0, the
          the beginning of that half-period.

             Differentiating with respect to t gives the
          first-order differential equation:

                              di    1
                            R --- + - i = 0
                              dt    C
          or
                            di        1
                            --- = - --- i     i
                            dt       RC

------------------------------------------------------------------ part=1, block=k ------ --


      block 1k,  x06m2b:


unit  :   x06m2b
back  :   x06m2a
next  :   x06m2c
at    :   507
write        The differential equation i

                              di    1
                            R --- + - i = 0
                              dt    C
          or
                            di        1
                            --- = - --- i     i
                            dt       RC
             Solves to

                                  t
                                - --
                            i = I  ε  RC   i
                                 0
          where I  is the current at t = 0 and ε = 2.71828,
                 0
          the base of natural logarithms.

             Any variable, whose rate of change at any instant
          is proportional to the value of that variable at that
          instant is of the natural exponential form, like i.
***   :

unit  :   x06m2c
back  :   x06m2b
next  :   x06m2d
at    :   507
write        Consider the term

                             ε- t/RC

             RC is called the time constant τ = RC.

          When t =  0, ε- t/RC = ε- 0/τ = ε0  = 1.00   i

          When t =  τ, ε- t/RC = ε- τ/τ = ε-1 = 0.37   i
```

When $t = 2\tau$, $\epsilon^{-t/RC} = \epsilon^{-2\tau/\tau} = \epsilon^{-2} = 0.14$

When $t = 3\tau$, $\epsilon^{-t/RC} = \epsilon^{-3\tau/\tau} = \epsilon^{-3} = 0.05$

When $t = 4\tau$, $\epsilon^{-t/RC} = \epsilon^{-4\tau/\tau} = \epsilon^{-4} = 0.02$

When $t = 5\tau$, $\epsilon^{-t/RC} = \epsilon^{-5\tau/\tau} = \epsilon^{-5} = 0.01$

Note that for any time $t_2 = t_1 + \tau$,

$\epsilon^{-t_2/RC} = \epsilon^{-1} \times \epsilon^{-t_1/RC} = 0.37\ \epsilon^{-t_1/RC}$

In other words, during any time interval $\Delta t = \tau$ the exponential function concerned will decrease to 37 % of its value at the beginning of that interval.

```
***

unit    x06m2d
term    test2
back    x06m2c
next    x06m2d1
at      1005
write      Let's apply the above theory to measure the time
        constant τ for the experimental RC circuit.

           Turn the A PRE AMP to OFF, to provide a baseline
        as we did before.  Also, set TIME at 500 μs and
        B VOLTS at 1 V, so you display one half-period of
        the current i.
***

unit    x06m2d1
pack    n33,a0bc00000000c00+bd0000ad000c00
join    ckc
goto    n47,x06s1c1,x06m2d2
***

unit    x06m2d2
pack    n33,jfoc(cd)(de)edba<f(rtu)g(ab)>d(ef)(tu)+aaa++1
join    ckd
jump    n47,x06s1c1,x06m2e
--------------------------------------------------------------- part=1, block=1 --------


     block 11,  x06m2e


unit    x06m2e
back    x06m2d
next    x06m2f
at      1007
write      Recall that 1 cm horizontally on this display
        is now equivalent to 50 microseconds, and, beginning
        at any point on the exponential curve, measure the
        time interval in which the current i decreases
        to 37 % of its initial value.

                        Time constant = τ =        μs
arrow   1642
long    2
ansv    92,10
no
at      1705
write      If the period of the current
        is still 1 ms, your measurement
        of τ should be in the range of
        80 to 100 μs.

           Try again, perhaps starting from some
        other initial time on the smooth curve.
***

unit    x06m2f
back    x06m2e
next    x06m2g
at      505
write      Another feature is significant for any first-order
        exponential curve. Recall that

                                                   t
                                                 - -
                   di     1          1
                   -- = - -- i = + - Ig ε        τ
                   dt     RC         τ

           At any time t1, the tangent to the current curve is
                   Δi     1
                   -- = - - i1
                   Δt     τ

           Consequently, if a tangent to the current curve is
        extend from time t = t1 to t = t1 + τ, the tangent
        line should end at i = 0.

           Since this should apply at any point on the
        decreasing curve, you now have another method of
        graphically checking whether the curve represents a
        first-order decreasing exponential function.
***

unit    x06m2g
back    x06m2f
term    test
at      205
write      You should now be able to answer the following
        questions pertinent to this experiment.

           1. What element supplies the energy dissipated in R
        during the second half-period when vg = 0 ?

           2. During the second half-period, i = Ig ε.t/τ.
        wherein Ig =              mA

arrow   650
specs   bumpshift
```

```
answer   (c,cap,capacitor)
wrong    (vg, generator, source)
arrow    918
ansv     -7.8,.5
inhibit erase
jump     x06m2g1
***

unit     x06m2g1
next     x06end
at       1105
write       3. During any half-period, the curve of pR(t)
         versus t is a first-order exponential function.

            What is the time constant of pR(t)?
calc     x⇐248
         y⇐205
         ymax⇐20
         xmax⇐10
join     x06s1b
graph    1.5,20,pr(t)
graph    1.5,-2,40
graph    9,-2,200 µsec
funct    (20)exp(-.6(v100)),v100⇐0,10,.5
at       1451
write    µsec
arrow    1444
ansv     40,5
wrong
join     x06s2c

----------------------------------------------------------- part=1, block=m ---------


        block 1m,  x06s1a


unit     x06s1a
at       1010
write       The output voltage is displayed as it was in
         earlier experiments.  Just connect the adjustable
         SQUARE OUTPUT of the Function Generator to A INPUT.

            The circuit current is not as easy to measure.
         The Scope is only capable of displaying a voltage
         not a current.  Using the basic equation v=iR,
         the current can be measured by interpreting each
         volt across the 100 ohm sampling resistor as
         10 milliampere.  Therefore, monitor the voltage
         at Terminal 3 and multiply it by 10 to read the
         current in mA.
end
***

unit     x06s1b
origin   x,y
```

```
axes    -75,-75,75,75
scalex  xmax
scaley  ymax
markx   2xmax,xmax/5
marky   2ymax,ymax/5
end
***

unit    x06s1c
next    x06m1e
erase
at      1007
write      You have not followed my suggestions carefully.

                          Try again please..
***

unit    x06s1c1
next    x06m2d
erase
at      1007
write      You have not followed my suggestions carefully.

                          Try again please..
***

unit    x06s1d
back    x06m1e
arrow   n100
store   v103
ansv    v101
arrow   n100+13
store   v(n1-24)
ansv    v102,.5
at      n100+26
showt   v103×v(n1-24)
calc    n1⇐n1+1
        v(n1)⇐v103×v(n1-25)
        n100⇐n100+200
***

unit    x06s1e
arrow   n100
store   v(n1-30)
ansv    v102,2
at      n100+10
showt   v(n1)
at      n100+21
showt   v(n1-30)×v(n1)
calc    v(n1-20)⇐v(n1-30)×v(n1)
        n1⇐n1+1
        n100⇐n100+200
***

unit    x06s1f
next    x06s1g
at      510
```

```
write      The graph you see below should look similar
        to the traces displayed on the oscilloscope.
        If it doesn't ask your instructor for assistance.

entry   graph
origin  248,150
axes    -140,-140,140,140
scalex  10
scaley  10
markx   2
marky   2
exit
funct   10exp(-.25(10+v150)),v150⇐-10,10,.5
gdraw   -10,0;-10,10;10,10;10,0
pause
mode    erase
at      510
write      The graph you see below should look similar
        to the traces displayed on the oscilloscope.
        If it doesn't ask your instructor for assistance.
mode    write
at      510
write      You can obtain five of the needed data points
        from this display read the voltage values at
        the ◆ on the horizontal axis.  Each data point
        has a current and a voltage reading.
           Slide the base line up or down to read any
        value that is off the screen.  When you read
        that value do not forget that the voltage is
        from the new base line.

---------------------------------------------------------- part=1, block=n ---------


        block in,  x06end


entry   points
graph   -9.8,0,◆
graph   -6,0,◆
graph   -2,0,◆
graph   2,0,◆
graph   6,0,◆
exit
***

unit    x06slg
at      510
write      For the other 5 data points the Trigger
        Slope slide switch is used.  Switch the
        Trigger Slope to trigger on the negative
        side of the wave.  This will give you the
        second cycle of the wave.  The traces seen
        on the scope should resemble the below graph.
join    graph
gdraw   -10,0;-10,-10.
```

```
funct   -10exp(-.25(10+v150)),v150⇐-10,10,.5
pause
mode    erase
at      510
write      For the other 5 data points the Trigger
        Slope slide switch is used.  Switch the
        Trigger Slope to trigger on the negitive
        side of the wave.  This will give you the
        second cycle of the wave.  The traces seen
        on the scope should resemble the below graph.
mode    write
at      510
write      You can obtain the final five data points
        from this display read the voltage and current
        values at the ◆ on the horizontal axis.
           As before the base line can be moved up or
        down to read values off the screen.
join    points
end
***

unit    x06s2c
at      2105
write   Known equations:
           p_r(t)=R_t×[i_c(t)]^2
           i_c(t)=I_max×exp[-t/τ_1]
at      2505
write      Rearranging the equations:   p_r(t)=R_t×I_max^2×exp[-2t/τ_1]

           Now a different time constant, τ_2, can be defined as τ_1/2
        This new time contant is the time constant for p_r(t).

                          p_r(t)=R_t×I_max^2×exp[-t/τ_2]
gdraw   0,20;2.2,0
end
***

unit    x06end
back    x06m2g
join    imode
jump    n47,x06end,x
course  n2
calcc   n2='ee244',
        nc(n21+1)⇐(nc(n21+1)$mask$o77777777770000000000)+o4603000000,
        nc(n21+1)⇐nc(n21+1)
erase
output  /// student has completed experiment ///
join    endunit
join    jmpmes
jumpout cgeindex,quest1

entry   leave
end     lesson
***

unit    endunit
course  n2
```

```
1106  jump     n2≠'ee244',leave,x
1107  calc     nc(n21+7)⇐nc(n21+7)+ahelp
1108           vc(n21+6)⇐vc(n21+6)+atime/60000
1109  ***Incl.cge s.r. & terms sample,index,imode,comment,slides.
1110  use      eex00,ck1
1111  use      ck2
1112  use      ck3
1113  use      ck4
1114  use      ck5
1115  use      ck6
      ckc             not found               252     846
      ckcw            not found                94     115     162       320    : 603
      ckd             not found               258     851
      ckdw            not found               100     121     168       326    : 609
      endunit   x06end          1104           18    1098
      graph     x06sla          1009         1052
      imode           not found                29    1090
      jmpmes          not found              1099
      leave     x06end          1101         1106
      points    x06end          1036         1071
      power     x06m1i           411          760
      replot    x06m1i           378          352
      replotv   x06m1n           679          655
      resisp    x06m1m           530          753
      resisw    x06m1m           545          756
      work      x06m1k           441          763
      x06end    x06end          1088          918    1091
      x06m0a    x06m0a            27           30      50
      x06m0b    x06m0a            49           31      72
      x06m1a    x06m0a            71           51      95     101  126  116  395  122
                                              697
      x06m1a1   x06m1a1           92           73
      x06m1a2   x06m1a1           98           96
      x06m1b    x06m1a1          104          102
      x06m1b1   x06m1a1          113
      x06m1b2   x06m1a1          119          117
      x06m1c    x06m1a1          125          123     143
      x06m1d    x06m1a1          142          127     163     169       174
      x06m1d1   x06m1a1          160          144
      x06m1d2   x06m1a1          166          164
      x06m1e    x06m1e           172          170     216     263  964  292  978  332
      x06m1f    x06m1e           215          175
      x06m1f1   x06m1e           250          248
      x05m1f2   x06m1e           256          254
      x06m1g    x06m1g           262          217     260
      x06m1h    x06m1g           291          264
      x06m1h1   x06m1g           311          293     312     324
      x06m1h2   x06m1g           323          321
      x06m1i    x06m1i           329          327     401     428
      x06m1i0   x06m1i           393          379     380
      x06m1i1   x06m1i           396          128
      x06m1j    x06m1i           400          398
      x06m1k    x06m1k           425          402     468
      x06m1k1   x06m1k           449          459
      x06m1l    x06m1k           465          429     504
      x06m1m    x06m1m           503          469     586
      x06m1m1   x06m1m           553          563
```

```
x06m1m3   x06m1m           568                 578
x06m1n    x06m1n           584                 505       601       607       613       699
x06m1n1   x06m1n           600                 587
x06m1n2   x06m1n           606                 604
x06m1o    x06m1n           612                 610       636
x06m1p    x06m1n           635                 614       765
x06m1q    x06m1q0          702                 700
x06m1q0   x06m1q0          694                 615       638       680       681
x06m1q0a  x06m1q0          698                 128
x06m1q1   x06m1q0          737                 747
x06m1q3   x06m1q0          749
x06m2a    x06m1q0          764                 703       792
x06m2b    x06m2b           791                 766       814
x06m2c    x06m2b           813                 793       834
x06m2d    x06m2b           832                 815       855       971
x06m2d1   x06m2b           844                 835
x06m2d2   x06m2b           849                 847
x06m2e    x06m2e           854                 852       877
x06m2f    x06m2e           876                 856       899
x06m2g    x06m2e           898                 878      1089
x06m2g1   x06m2e           917                 915
x06s1a    x06s1a           939                  74       145
x06s1b    x06s1a           954                 184       219       296  531  412  546  442
                                               620       716       723       927
x06s1c    x06s1a           963                 254       260
x06s1c1   x06s1a           970                 847       852
x06s1d    x06s1a           977                 357       359       361  368  363  370  365
                                               372       374       376
x06s1e    x06s1a           991                 659       661       663  669  665  671  667
                                               673       675       677
x06s1f    x06s1a          1003                 331
x06s1g    x06end          1044                1004
x06s2c    x06end          1074                 937
ahelp                     1107
atime                     1108
back                       352       380       655       681
exp                        226       301       625       625       931       1017      1054
i                          223
key                        352       380       655       681
nc                        1094      1094      1095      1095      1107       1107
n1                         354       657       683       686       688  986  690  987  983
                           987       988       988       993       996  999  998  999  998
                           999      1000      1000
n100                       353       656       682       685       687  691  689  979  691
                           982       985       989       989       992 1001  995 1001  997
n111                       445       450       450       452       549  556  554  565  554
                           569       569       571       726       738       738       740
n120                       176
n121                       177
n122                       178
n123                       179
n130                       447       450       450       452       457  554  457  554  551
                           556       561       561       566       569  576  569  576  571
                           728       738       738       740       745       745
n132                       448       454       454       458       458  558  459  555  552
                           562       562       563       567       573  577  573  575  577
                           729       742       742       746       746       747
```

```
n149     417   419
ni50     418   419   419   421    422  688  684  690  686
n2      1092  1093  1105  1106
n21     1094  1094  1095  1095   1107       1107 1100 1108
n33       93    99   114   120    161  257  167  319  251
         325   602   608   845    850
n47       30    95    96   101    102  122  116  123  117
         163   164   169   170    254  327  260  604  321
         610   847   852  1091
n94      221   222   222   226    226  300  226  300  299
         301   301   301   624    625       625  625  625
n95      220   222   226   227    227  625  623  626  625
         626   626
n99       25    32   128   395    397  696  615  696  696
         697   699
Pc       717
Pg       297   414
Pr       532   928
t        186   223   297   298    414  444  415  532  443
         533   547   548   621    622  724  717  725  718
         928
v        419   450   450   452    554  569  554  569  556
         571   686   688   690    730  738  730  738  732
         740   983   986   988    988  998  993  998  996
         999   999   999
vc      1108  1108
vi       534   535   535   535    535  536  535  536  536
         536   536   557
v100     226   226   301   301    625  931  625  931  625
v101     355   367   981
v102     356   358   360   362    364  371  366  373  369
         375   658   660   662    664  670  666  672  668
         674   676   984   994
v103     980   986   988
v105     382   413
v106     383   413
v107     384   413
v108     385   413
v109     386   413
v112     446   453   453   454    455  463  460  550  460
         557   557   558   559    564  572  564  573  572
         574   579   579   582    727  734  733  735  733
         741   741   742   743    748       748
v131     450   452   554   556    569  732  571  738  730
         740
v133     452   453   556   557    571  733  572  740  732
         741
v134     446   454   455   550    558  574  559  727  573
         734   735   742   743
v140     451   452   454   454    555  558  556  570  558
         571   573   573   731    732  739  734  740  734
         742   742
v150    1017  1017  1054  1054
v60      719
v61      719
v62      719
v63      719
```

```
v64             719
v65             719
v66             719
v67             719
v68             719
v69             719
v80             382    516    516    534    535
v81             383    535
v82             384    535
v83             385    535
v84             386    535
v85             387    536
v86             388    536
v87             389    536
v88             390    536
v89             391    536
vg              186
vC             621
wc              724
wg              443
wr              547
x               176    180    400    437    527  721  616  750  713
                754    757    762    923    955
xmax           178    183    407    439    529  926  619  937  714
                959    959
y               177    181    218    294    409  543  438  617  526
                712    720    751    759    924       955
ymax           179    182    295    406    436  618  528  715  544
                722    752    755    758    761  960  925  960  958
◆               419    422    1037   1038   1039      1040      1041
µsec            930

                        lesson information

lesson name = eex06

starting date = 03/29/73

last edited on 08/21/74 at 11.26.37

          by neal of course eecge

          at site 7, station 27

author name = J P Neal

department = EE

telephone number = 333-4351

discipline = EE

grade level = Freshman

descripion of lesson = Measurements of Transients.
```

```
     block 1a,   eex07id

stop
****     For Neal, CGERL, Room 248, EEB.

One line description of this lesson --

   Measurements of Impedance.

               Divisions of this Lesson:        Block     Unit

          Id for this file                      eex07id
          Experiment eex07;
            Objectives                          eex07id   x07m0a
            Measure impedance magnitude         x07m1a    x07m1a
            Time displacement method            x07m1d    x07m2a
            Lissajous figure method             x07m2e    x07m3a
            Calc.impedance from components      x07m4a    x07m4a

          final edit 21 aug 74 neal.

*list   info
*list   symbols
*list   varian,charset,cgeindex,cgechar
****
start
finish  endunit
write   <at,1010> Loading the CGE Character Set
charset cgeindex,cgechar
erase
zero    n99               $$ used for restart skipping
dataon
area    eex07
ext     0
***

unit    x07m0a
restart
join    imode
jump    n47,x07m0a,x
calc    n55⇐-1           $$ used in review seq.
calc    n99⇐-1           $$ n99 = 0 if restart
at      509
write                MEASUREMENTS OF IMPEDANCE

        When you have completed this experiment, you
        should be able to:

        1)   Experimentally measure the magnitude of an
        impedance.
```

```
            2)   Measure the time-phase relation between two
            waveforms by the time-displacement method.

            3)   Measure the time-phase relation between two
            waveforms by the Lissajous-figure method.

            4)   Calculate the theoretical impedance of a
            series circuit and compare this value with the
            actual laboratory measurement.

------------------------------------------------------------ part=1, block=b --------


      block 1b,  x07m1a


 unit     x07m1a
 base
 back     x07m0a
 next     n55,x07m1b,x07m3e
 at       307
 write       Consider a two-terminal electrical device driven
          by a single-frequency sinusoidal power source and
          having an input voltage v and input current i:

                                   i
                                      →
 draw     198,391;240,391
 circle   8,227,375
 draw     166,375;219,375;skip;234,375;284,375
 at       921
 write    ◆         Z        ◆
          +         v        -
 at       1205
 write       When displayed on the SCOPE, the convenient
          measures of a sine wave are Vpp and the time angle
          after t = 0 at which the wave is positive-going
          through v = 0.  We will use the input current i
          as the time reference, and thus show it by

             i = I0p sin ωt = 0.5Ipp sin ωt

             Now, the input voltage leads or lags the input
          current by a time-angle equal to or less than π/2
          or 90°.  Hence, the expression for the input voltage
          can be shown by

             v(t) = V0p sin (ωt + θ) = 0.5Vpp sin (ωt + θ)

          where -90° ≤ θ ≤ 90°.

 unit     x07m1b
 back     x07m1a
 next     x07m1b1
 at       505
 write       In terms of the input voltage and current of a
```

two-terminal circuit element, we will define the impedance of that element by

$$Z = |Z| \angle\theta$$

where $|Z| = V_{pp} / I_{pp}$

θ = the angle by which the voltage leads the current, as shown in the equations on the preceding display.

Our present task is to measure $|Z|$, the magnitude of the impedance of an inductive two-terminal circuit.

Select the IMPEDANCE BOARD, ITEM 35 from the shelf below, and connect the sensor cable securely in the panel connector below the Function Generator.

When you have connected the circuit-board sensor cable, connect the circuit diagrammed on the next display.

```
***

unit    x07m1b1
back    x07m1b
next    x07m1b
join    x07s1a
pause
pack    n33,a0a0000000b0c0caba00000+00ba00
join    ckc
jump    n47,x,x07m1c
pack    n33,a0a0000000b0c0caba00000+00ba00
join    ckc2w
***

unit    x07m1c
back    x07mib
join    x07s1b
at      2007
write
```

The connection diagram requires the display of the voltage across the switch-selected impecance on A channel of the SCOPE, and the voltage of the current-sensing resistor on B channel, so

$$|v_B| = |i_Z| \times 100$$

Therefore : $|i_Z| = 10 \times |v_B|$ (milliamperes)
As connected, $v_B = -i_Z \times 100$. In order to display $+i_Z$, set the B PRE AMP at AC-.

```
------------------------------------------------------------- part=1, block=c --------

        block 1c,  x07m1d

unit    x07m1d
```

```
back    x07m1c
next    x07m1d1
at      707
write      Set the equipment so that:

           Two periods of a 2 kHz sine wave with Vpp = 20 V
        are displayed on channel A of the SCOPE.

           Externally trigger the SCOPE from the A INPUT
        for a stable display and use the AC EXT setting.

           Set the A PRE AMP at DC+, and the B PRE AMP at -DC.
***

unit    x07m1d1
next    x07m1d
pack    n33,+(gh)(nop)d(cd)dc(ad)b+++++++++(fg)<c(bc)b(uv)>+
join    ckdw
jump    n47,x,x07m1e
***

unit    x07m1e
back    x07m1d
at      708
write      What is the value of Ipp ?

                          milliamperes (mA)
arrow   908
ansv    2.9,.15
wrongv  .29,.015
at      1510
write   For the current-sensing resistor

        |Ipp| (milliamperes) = |VB pp| × 10
wrongv  -2.9,.15
at      1510
write   A peak-to-peak value cannot be a negative number.
no
at      1507
write      You should recall that iZ = -10 × vB , where
        iZ is in milliamp and VB is the voltage displayed
        on channel B. Be sure to set B VOLTS so that a
        large-size waveform is displayed on the CRT.
endarrow
at      1307
write      Recalling that Z = V , what is the magnitude
                              -
                              I
        of the impedance?

        |Z| =                     kΩ
at      1906
write   NOTE: As this experiment requires numerous calculations,
        a calculator is provided for your convenience.

           Simply enter the expression you need to evaluate.
join    x07s4e
arrow   1713
```

```
ansv     7.14,
***

unit     x07m2a
back     x07m1e
at       505
write       Now that you have seen how to measure the magnitude
         of an impedance, we will next measure the angle of
         that impedance.

            As stated earlier v and i have certain time angles
         with respect to t = 0.  We selected the time-reference
         angle of the current as 0.  Consequently, the time-
         reference angle of the voltage is θ, the angle by which
         the voltage leads or lags the current, that is, the
         angle of the impedance.
------------------------------------------------------------ part=1, block=d ---------


      block 1d,  x07m2b


unit     x07m2b
back     x07m2a
next     n55,x07m2c,x07s2b
at       505
write       We will now measure θ for the selected impedance
         on the circuit board, by the time-displacement method.

            If Δt is the time interval by which the voltage leads
         the current, or the current lags the voltage, on the SCOPE
         display, we can calculate θ using the following relations

                 i(t)  = I0p sin ωt

                 v(t)  = V0p sin ω(t + Δt)  = V0p sin (ωt + θ)

         where θ = ωΔt = 2πfΔt = 2π(Δt/T)

            In the sinusoidal expressions, angles are in radians
         and ωT = 2π.  However, in circuit calculations it is most
         convenient to use angles in degrees, where 2π radians
         is equivalent to 360°.  Hence, to measure θ on the SCOPE
         simple determine the fraction of the period T by which
         the voltage leads the current and multiply that fraction
         by 360° to evaluate θ.  Incidentally, to type the
         degree sign, simply press -MICRO- and type o.
***

unit     x07m2c
next     x07s2a
back     x07m2b
at       405
write       Set the equipment so that:
```

```
          The SCOPE is triggered externally by the A INPUT.

          Both the A and B INPUTs are displayed in the ALTernat
          mode, with the A PRE AMP at DC+ and the B PRE AMP at -DC.
          With the B PRE AMP set in this manner, i(t) will be
          displayed rather than -i(t).

             The AUDIO OSCILLATOR should still supply Vpp = 20 V
          at a frequency of 2 kHz to the A channel of the SCOPE.

             It is  not necessary to change any connections.
***

unit      x07m2d
base
jump      n99,x,x07m3a
back      x07m2c
next      x07m2e
help      x07s2b
at        2410
write     -HELP- is available.
at        505
write        By what time interval does the current lag the voltage.

                       milliseconds.
arrow     705
store     v60
ansv      0.08,0.02
at        905
write        What is the period T of the sine waves, as
          displayed on the SCOPE ?

                       milliseconds.
arrow     1205
store     v61
ansv      .5,.02
endarrow
at        1305
write        Recalling that θ = (Δt/T) × 360°, what is θ ?
join      x07s4e
arrow     1710
ansv      (v60/v61)*360,2

----------------------------------------------------------------- part=1, block=e --------


      block 1e,  x07m2e


unit      x07m2e
calc      n51⇐-1             $$ used in x07m2f goto and writec
base
back      x07m2d
next      x07m2f
join      x07s2c
join      x07s2d
```

```
at       1126
write    ← LEADING waveform
at       1531
write    ← LAGGING waveform
pause
mode     erase
join     x07s2d
mode     write
join     x07s2e
pause
mode     erase
join     x07s2e
mode     write
join     x07s2f
***

unit     x07m2f
base
back     x07m2e
lab      x07s2d
help     x07s2e
at       805
write       Set the impedance-selector switch to position 5.
         Is v(t) for this circuit leading or lagging?
         ____________
at       101[illegible]
writec   n51,,lagging          $$ inserts previous response
goto     n51,x,x07m2f1
arrow    1010
answer   lagging
no
at       1205
write       Remember, v(t) is display on channel A; i(t)
         on channel B. Press -LAB- to review the
         definitions of leading and lagging.
endarrow
addl     n51

entry    x07m2f1
at       1410
write    Is θ positive or negative? ____________
at       1438
writec   n51,,,negative
goto     n51,x,x,x07m2f2
arrow    1438
answer   negative
no
at       1610
write    θ for a a lagging v(t) is negative
endarrow
addl     n51

entry    x07m2f2
at       1710
write    Thus, this circuit is: ____   (type a,b,or c)

                    a) inductive
                    b)capacitive
                    c)resistive
arrow    1733
answer   b
no
at       2309
write    Press -HELP- for assistance and/or an explanation.
endarrow
at       2409
write    Return the impedance selector switch to position
         3 before proceeding.
***

unit     x07m3a
restart
base
back     x07m2e
next     x07m3b
help     n99,x,x07s1a
data     n99,x,x07m2c
at       1005
write       The next method for measuring phase angles is
         the Lissajous figure method. Before continuing,
         however, recheck the balance of both SCOPE
         channels and the positioning of the 0,0 point
         on the SCOPE grid.
at       2010
writec   n99• •Press -HELP- to see the circuit diagram

         Press -DATA- for dial settings.

------------------------------------------------------------------ part=1, block=f -----------


     block 1f,  x07m3b


unit     x07m3b
zero     n52                $$ needed for proper use of x07s3a
back     x07m3a
next     x07s3c
at       305
write       To obtain a Lissajous figure from your
         present circuit, set the Y DISPLAY FUNCTION
         to A vs B and turn OFF the SWEEP MODE.

            Press -NEXT- when you have finished.

            Press -DATA- to see a typical Lissajous figure.
pause
keytype n51,data,next,back
goto     n51,x,x07s3a,x
jump     n51,x,x,x07s3c,x07m3a
***

unit     x07m3c
```

```
next      n55,x07m3d,x07m3e
back      x07m3b
at        205
write        The Lissajous figure on display is a plot of

          y = Vm sin (ωt + θ)   versus   x = Im sin ωt.

             θ can be evaluated from the ratio of M = 2v(t) at t = 0,
          to N = Vpp.    Thus:

entry     x07m3c1
at        1007
write     2Vm sin(ωt+θ)|ωt=0        2Vm sin(0+θ)                M
          ------------------   =   -------------- = sin θ  =  -
          2Vm sin ωt|ωt=π/2         2Vm sin 90°                 N
join      x07s3a
join      x07s3b
***

unit      x07m3d
base
next      x07m3e
back      x07m3c
help      x07m3c1
calc      n52⇐-1                            $$ needed for x07s3a
at        305
write        From the Lissajous pattern displayed on the SCOPE,
          measure:

                        M (t = 0)          __________ Volts

                        N (at Vmax)        __________ Volts

                        θ (=arcsin M/N)    __________ °


                              -HELP- is available
arrow     630
store     v120
ansv      8.4..6
arrow     830
store     v121
ansv      10.1.1
no
at        1605
write        A convenient method for measuring N is to turn
          the B PRE AMP to OFF.
endarrow
join      x07s3f
arrow     1030
ansv      v102,5%
***

unit      x07m3e
base
at        405
```

```
write      Recall our definition of impedance Z:

                       Z = |Z| ∠θ

             You should now be able to calculate the
          magnitude, |Z|, and its phase angle θ.

          Press -HELP- to review measurements of magnitude.

          Press -DATA- to review the use of the time displacement
          method in calculating θ.

          Press -LAB-  to review the use of the Lissajous
          figure in determining θ.

          Press -NEXT- to continue.
pause
keytype n55,next,back,help,data,lab
jump    n55,x07m4a,x07m4a,x07m3d,x07m1a,x07m2b,x07m3c
--------------------------------------------------------------------------------------- part=1, block=g -----------


      block 1g,   x07m4a


unit      x07m4a
imain     x07s4g
at        405
write            Thus far we have expressed impedance in the
          polar form, Z = |Z| ∠θ. Another representation is
          the rectangular or complex form:

                     Z = R + jX      where j = √-1

          in this expression, R is termed the resistive component
          and X is called the reactive component.

             For converting from the polar form to the rectangular
          from, use of Euler's identity gives:

              R = |Z| cos θ  and  X = |Z| sin θ

             Similarly, to convert from the rectangular form
          to the polar form, use the identities:

             |Z| = √R² + X²    and  θ = arctan ( X/R )

             Since these identities will be useful in the
          remainder of this experiment, you may obtain
          this display hereafter by pressing -SHIFT-DATA-.

               Press -NEXT- to continue.
end
next      x07m4b
***
```

```
unit    x07m4b
back    x07m4a
at      505
write     For a SERIES circuit, R is the sum of the
        resistances in the circuit. (Caution: this is
        not true for a parallel circuit).

          Individual series-element reactances are related
        to the element parameters, i.e., capacitance and
        inductance, and the frequency by the formulas:

          X_L = ωL = 2πfL    (recall ω = 2πf )

                    1         1
          X_C = - ---- = - -----
                   ωC       2πfC

          X = X_L + X_C

          These formulas will also be useful in the
        remainder of this experiment, you may obtain this
        display hereafter by pressing -SHIFT-LAB-.
end
next    x07m4c
***

unit    x07m4c
base
back    x07m4c
next    x07m4c1
at      605
write     In a given circuit, one may measure either
        R and X, or |Z| and θ_z, and expect the results
        to be in agreement with one another.

          Set the Impedance Selector Switch to position 2.
***

unit    x07m4c1
pack    n33,aa00000000b0c0caba00000+00ba00
join    ckc
jump    n47,x07m4c,x07m4d
pack    n33,aa00000000b0c0caba00000+00ba00
join    ckc2w
***

unit    x07m4d
zero    n59               $$ used in next goto and writec
base
back    x07m4c
next    x07m4e
help    x07s4b
at      705
write     Using the same 20 V p-p, 2 kHz signal from the
        AUDIO OSCILLATOR, determine the magnitude of this
        new impedance, Z.
```

```
         |Z| = ____________ kΩ

                 -HELP- is available
join     x07s4e
arrow    1118
store    v50
ansv     3.5,10%
```

```
-------------------------------------------------------------------- part=1, block=h -----------
```

```
      block 1h,  x07m4e

unit     x07m4e
base
back     x07m4d
next     x07m4f
help     x07s4d
lab      x07s2e
at       705
write       To complete this calculation of Z in the polar
         form, Z = |Z| ∠θ , determine θ by the time-
         displacement method.

            Recall that θ = Δt/T

         enter T  = ___________ milliseconds

         enter Δt = ___________ milliseconds
at       2420
write    -HELP- is available
at       1318
writec   n59,‹s,v61›,,
at       1518
writec   n59,‹s,v60›,,
goto     n59,x07m4e1,x
arrow    1316
store    v61
ansv     .5
no
at       12
write    Set the frequency so T =.5 ms.
endarrow
arrow    1516
store    v60
ansv     .04,.05
endarrow
calc     n59⇐-1

entry    x07m4e1
at       1910
write    enter θ = ___________ °
join     x07s4e
arrow    1922
store    v51
```

```
ansv    -(v60/v61)×360,1
wrongv  (v60/v61)×360,1
at      2105
write      Recall that θ for a capacitive circuit is negative.
        Press -LAB- for an explanation.
***

unit    x07m4f
base
back    x07m4e
next    x07m4g
calc    v52⇐sin(v51°)
calc    v53⇐cos(v51°)
at      410
write      You have calculated Z in the polar form as

                Z = |⟨s,v50⟩ kΩ| /⟨s,v51⟩°

           Using the identities available by pressing
        -SHIFT-DATA- , express Z in the rectangular
        form as Z = R + jX.

                R = ______________ kΩ
at      1616
write   sin (⟨s,v51⟩°) = ⟨s,v52⟩

        cos (⟨s,v51⟩°) = ⟨s,v53⟩
at      1223
writec  n59,,⟨s,v54⟩
goto    n59,x,x07m4f1
join    x07s4e
arrow   1221
store   v54
ansv    v53×v50,10%
no
at      1237
write   Units of Z and R are kΩ.
endarrow
zero    n59

entry   x07m4f1
at      1416
write   X = ______________ kΩ
join    x07s4e
arrow   1421
store   v55
ansv    v52×v50,10%
wrongv  -(v52×v50),10%
at      1437
write   You need a minus sign.
no
at      1437
write   Units of Z and X are kΩ.

------------------------------------------------------------ part=1, block=1 ---------
```

```
     block 1i,  x07m4g

unit     x07m4g
base
back     x07m4f
next     x07m4h
help     x07s4f
join     x07s1b
at       144,428
erase    4
at       144,428
write    ◆
at       520
write    ↗
catchup
at       2005
write       Using the reactance equations which are available
         by pressing -SHIFT-LAB-, calculate the theoretical
         value of the impedance of circuit 2, and express
         Z in rectangular form, R + jX

           R = ___________ kΩ
at       2514
writec   n59,,,<s,v56>
goto     n59,x,x,x07m4g1
arrow    2511
store    v56
ansv     3.3
wrongv   3.4
at       2705
write       Voltage is measured between Terminal 15 and ground
              Note that the 100Ω resistor is not included in
         this measurement.  It is used only for sensing the
         impedance current.
no
at       2708
write    For a series circuit, R is the sum of resistors.
endarrow
calc     n59⇐1  $$ avoids rewriting after branching key hit

entry    x07m4g1
at       3203
write    -HELP- is available
at       2532
write    X = ___________ kΩ
join     x07s4e
arrow    2536
store    v57
ansv     -1.6,10%
wrongv   -1600,10%
at       2631
write    Check your units.
wrongv   1.6,10%
at       2631
write    Almost! You forgot the minus sign
```

```
***

unit    x07m4h
base
back    x07m4g
next    x07end
at      509
write       You have measured the impedance of circuit
        2 and expressed it in polar form as:

                 Z = |<s,v50> kΩ| ∠<s,v51> °

            You converted Z to the rectangular form and expressed
        Z as:

        1)       Z = <s,v54> kΩ + j( <s,v55>) kΩ

            Finally, you calculated the theoretical value of
        Z in rectangular form and found:

        2)       Z = <s,v56> kΩ + j(<s,v57>) kΩ

            If the measured value of Z, equation 1, differs
        greatly from the theoretical value, equation 2,
        you may wish to discuss the discrepancy with your
        instructor. Bear in mind, however, that the values
        of the components used to obtain equation 2 are rated
        at ± 10%. Also, recall the inherent ± 3% error en-
        countered when reading oscilloscope measurements.
---------------------------------------*------------------------- part=1, block=j --------


          block 1j,  x07s1a


unit    x07s1a
draw    313;337;737;713;313
circle  29,152,432
draw    341;349;849;841;341
circle  23,352,432
circle  8,352,432
circle  3,352,390
circle  3,340,390
circle  3,363,390
at      336,373
write   ⊥
circle  3,208,416
circle  3,264,416
draw    1719;1741;2341;2319;1719
circle  3,160,208
circle  3,160,160
circle  3,304,176
circle  3,208,406
circle  3,264,406
at      261,388
```

```
671  write   ⏚
672  at      205,388
673  write   ⏚
674  draw    1921;1221;1224;624;627;skip;208,406;224,406
675          224,319;352,319;352,176;304,176;skip;352,390
676          352,353;184,353
677  at      181,349
678  write   ◆
679  draw    2221;2421;skip;363,389;363,128;2421;skip;634;639
680          1139;363,336
681  at      360,332
682  write   ◆
683  at      2322
684  write   IMPEDANCE BOARD
685  at      2137
686  write   15
687  at      2221
688  write   11
689  at      1922
690  write   1
691  at      526
692  write   θ
693  at      533
694  write   θ
695  draw    2221;2233
696  at      256,156
697  write   ^^v-
698  draw    2237;2239;2139
699  at      248,163
700  write    100Ω
701  at      1623
702  write   current-sensing
703          resistor ___
704  at      268,228
705  write   |
706          |
707          |
708          ↓
709  draw    1921;1924;1824;1830;2030;2024;1924;skip;1930;1939
710          2139
711  at      1905
712  write   set switch to
713          connect
714          Term. 1 to 3
715  draw    109,197;160,197
716  at      159,193
717  write   •
718  at      950
719  write   NOTE:
720          AUDIO OSC.
721          ground strap
722          should be dis-
723          connected.
724  draw    949;345,368
725  at      342,368
726  write   ↑
727  draw    123,432;180,432;skip;520;152,460;152,403
```

```
at       1016
write     VA →
at       929
write      VB →
circle   3,232,406
draw     232,406;630;627
at       427
write    trigger
         input
           ↓
at       221
write    SET UP THIS CIRCUIT
at       2819
write    Press -NEXT- when finished
end
```

```
------------------------------------------------------------------- part=1, block=k --------
```

block 1k, x07s1b

```
unit     x07s1b
circle   8,104,432
draw     515;519
at       144,428
write    ●——→
at       176,428
write    ●
at       172,444
write    ●
at       173,412
write    ▲
at       161,400
write    ●
at       144,396
write    ●
at       419
write
draw     147,397;147,368
at       1019
write    |

         |
at       1013
write    3.3kΩ
at       1021
write    .05μF
draw     168,404;216,404;928
at       213,352
write    ╪

         |
at       1030
write    .5H
draw     623;635;835
```

```
778  at      269,368
779  write   |
780          B
781          |
782          |
783  draw    524;530
784  at      232,420
785  write   -ŪŪ-
786  draw    534;543;943
787  at      333,352
788  write   ⟨
789          ⟨
790          |
791  at      1037
792  write   3.3kΩ
793  at      630
794  write   .5H
795  draw    423;325;334
796  at      264,460
797  write   -||-
798  draw    336;351;951
799  at      397,352
800  write   ⟨
801          ⟨
802          |
803  at      1045
804  write   3.3kΩ
805  at      256,444
806  write   .05µF
807  circle  8,400,304
808  draw    1251;400,311
809  draw    1350;147,304;147,321
810  at      213,304
811  write   |
812  at      269,304
813  write   |
814  at      333,304
815  write   |
816  draw    400,296;1551;1545
817  at      320,268
818  write   ⌃⌃⌄-
819  draw    1541;1515
820  circle  8,104,272
821  at      320,276
822  write   100Ω
823  at      1352
824  write   15
825  at      1413
826  write   11
827  at      413
828  write   1
829  at      425
830  write   2
831  at      525
832  write   3
833  at      625
834  write   4
```

```
at      100,402
write   5
at      155,391
write   6
at      1724
write   IMPEDANCE   ITEM 35
draw    1810;1855;155;110;1810
at      1422
write   current-sensing
        resistor ──────→
at      1712
write   VB
at      312
write   VA
draw    1352;1356
at      440,300
write   —
at      452,288
write   ⊥

-------------------------------------------------------------- part=1, block=1 --------
```

```
     block 11,  x07s2a

unit    x07s2a
next    x07m2c
pack    n33,(ij)(fgh)(no)d(cde)(de)cdb+++++++++(fg)<b(uv)c(bcd)>+
join    ckd
jump    n47,x,x07s2a1
pack    n33,(ij)(fgh)(no)d(cde)(de)cdb+++++++++(fg)<b(uv)c(bcd)>+
join    ckdlw
***

unit    x07s2a1
next    x07m2c
pack    n33,a0a0000000b0c0caba00000+00ba00
join    ckcw
jump    n47,x,x07m2d
***

unit    x07s2b
next    n55,x,x07m3e
at      507
write      In order to measure the time delay between
        two sine waves, you must measure the distance
        between a given position on the reference wave
        and the same relative position on the displaced
        wave.
                                Note that both waveforms
                                are adjusted to be symetrical
                                about zero volts.
join    x07s2c
catchup
vbar    x,4,1,1
```

```
hbar    π/2,1,-
hbar    3π/2,-1,-
hbar    3π/4,.5,-
hbar    7π/4,-.5,-
locate  0,.8
write   ←Δt→
end
***

unit    x07s2c
origin  1815
axes    0,-128,256,128
scalex  2π
scaley  1
labely  1,.25
markx   π,.25π
funct   sin(v70),v70⇐0,2π,.02π
funct   sin(v70-.25π)×.5,v70⇐0,2π,.02π
***

unit    x07s2d
at      305
write      The following convention has been adopted
        regarding the sign of θ.  Consider the
        positive going slopes of the two waveforms.
        The waveform whose peak appears on the left
        is said to LEAD the other. Correspondingly,
        the sinusoid whose peak appears on the right
        is said to LAG the other.
end
***

unit    x07s2e
at      305
write      The impedance angle θ is defined as the
        angle of the voltage wave with respect to
        the current wave. Thus, if v(t) is leading,
        θ is positive (inductive circuit); if v(t)is
        lagging, θ is negative (capacitive circuit);
        if v(t) is neither leading nor lagging, θ
        is zero (resistive circuit).
end
***

unit    x07s2f
at      305
write      Note that the voltage waveform (displayed
        on channel A) for this circuit leads the
        current waveform; thus, θ is positive, i.e.,
        an inductive circuit.
***

unit    x07s3a
calc    v141⇐50
calc    v141⇐(v141)°
calc    v141⇐abs(v141)+.000001°
calc    v141⇐cos(v141)/sin(v141)
```

```
origin   2132
axes     -120,-120,120,120
scalex   5
scaley   5
markx    1,.5
marky    1,.5
calc     v142⇐4/(sqrt(16-16(v141^2/(v141^2+1)))+4v141sqrt(v141^2/(v141^2+1)))
funct    v142×(    sqrt(16-v140^2)+v141×(v140)),v140⇐-4,+4,.1
funct    -v142×(sqrt(16-v140^2)-v141×(v140)),v140⇐-4,+4,.1
goto     n52,x07s3b,x
end
```

```
-------------------------------------------------------------- part=1, block=m ---------
```

```
          block 1m,  x07s3b
```

```
unit     x07s3b
gdraw    -8,-3;0,-3
gdraw    -7.25,-2.75;-7.25,0.75
gdraw    -7.25,2;-7.25,2.75
gdraw    -8,3;0,3
gdraw    -2,-4;8,-4
gdraw    3,4;8,4
gdraw    7.25,-3.75;7.25,0.75
gdraw    7.25,2;7.25,3.75
size     2
graph    -9,1.2,2 A
         5.7,1.2,2 B
size     0
end
***

unit     x07s3c
pack     n33,(ij)+(no)d+(de)ce++++++++++(fg)<c(bcd)b(uv)>+
join     ckd
jump     n47,x07s3d,x
pack     n33,a0a000000b0c0caba0000+00ba00
join     ckcw
jump     n47,x,x07m3c
pause
jump     x07m3b
***

unit     x07s3d
base
next     x07m3b
help     x07s3e
at       309
write    You have incorrectly set the dials.

         Press -NEXT- to try again

         Press -HELP- for a listing of your errors
```

```
                Press -DATA- to see a typical Lissajous figure.
pause
keytype n51,data,next,help
goto     ~~n51,x,~~x07s3a,x
jump     n51,x,x,x07m3b,x07s3e
***

unit     x07s3e
pack     n33,(ij)+(no)d+(de)ce++++++++++(fg)<c(bcd)b(uv)>+
join     ckd1w
pause
jump     x07m3b
***

unit     x07s3f
at       2510
write    ARCSIN CALCULATOR ( enter M/N )
arrow    2720
store    v109
ansv     v120/v121,5%
endarrow
calc     v102⇐45°
calc     v101⇐0°
calc     v103⇐90°

entry    x07m3d1
calc     v110⇐v109-sin(v102)
goto     .000001>abs(v110),x07m3d2,x
calcc    0 v110,v103⇐v102,v101⇐v102
calc     v102⇐(v101+v103)/2
goto     x07m3d1

entry    x07m3d2
calc     v102⇐(180/π)*v102
at       2920
write    θ = <t,v102>
at       3110
write    Press -NEXT- to enter θ above
pause
***

unit     x07s4b
base
at       705
write       Recall that the Y Display Function must be

         set to A & B ALT.   Also, |Z| = |Vpp|, where
                                         -----
                                         |Ipp|

            v is displayed on channel A, and channel B
         displays .1|i| where i is in milliamps.
at       1610
write    Press -NEXT- when you have correctly set then dials.
pause
pack     n33,(ij)(fgh)(no)d(cde)(de)cdb+++++++++(fg)<b(uv)c(bcd)>+
join     ckdw
next     n47,x07s4b,x
```

```
jump     n47,x,x07s4c
***

unit     x07s4c
next     x07m4e
at       707
write    |Ipp| = _____________ milliamps
arrow    715
ansv     5.7,10%
no
at       907
write    Recall that |i| = 10 |vB|, where i is in milliamps.
endarrow
at       1011
write    |Z| = _____________ kΩ
join     x07s4e
arrow    1018
store    v50
ansv     3.5,10%
------------------------------------------------------------------ part=1, block=n --------


       block 1n,  x07end


unit     x07s4d
next     x07m4e
help     x07s4d1
data     x07s2b
at       1108
write    Press -HELP- for explanations on setting the dials.

         Press -DATA- for assistance in determining θ.
***

unit     x07s4d1
base
next     x07s4d
join     x07m2c
pause
pack     n33,(ij)(fgh)(no)d(cde)(de)cdb+++++++++(fg)<b(uv)c(bcd)>+
join     ckdw
jump     n47,x,x07m4e
***

unit     x07s4e
mode     erase
at       3219
write    Press -NEXT- to enter your answer above
mode     write
at       2837
erase    20
at       2938
erase    15
catchup
```

```
draw     2717;2757;3057;3017;2717
at       2819
write     CGE Calculator.
         Enter Expression:
                                 =
arrow    2837
store    v100
ok
endarrow
at       3038
show     v100
at       3219
write    Press -NEXT- to enter your answer above
pause
***

unit     x07s4f
at       511
write       The important equation for use in calculating
         the reactance, X, is:

                jX  =  1    = j  (-   1   )
                  c   ---           ----
                      jωC           2πfC

         where f = 2,000 Hz.

         'π', if you would prefer to use the symbol,
         is obtained by pressing -MICRO- then pressing -p-.

            Note that your answer is requested in units
         of kΩ, where k = 10³. The capacitance shown on
         the diagram is rated in units of μF, where μ= 10⁻⁶.
end
***

unit     x07s4g
data1    x07m4a
lab1     x07m4b
***

unit     x07end
back     x07m4a
join     imode
jump     n47,x07end,x
course   n2
calcc    n2='ee244',
         nc(n21+1)⇐(nc(n21+1)$mask$o77777777770000000000)+o4603000000,
         nc(n21+1)⇐nc(n21+1)
erase
output   /// student has completed experiment ///
join     endunit
join     jmpmes
jumpout  cgeindex,quest1

entry    leave
end      lesson
***
```

```
1126 unit     endunit
1127 course   n2
1128 jump     n2≠'ee?44',leave,x
1129 calc     nc(n21+7)⇐nc(n21+7)+ahelp
1130          vc(n21+6)⇐vc(n21+6)+atime/60000
1131 ***Incl.cge s.r. & terms sample,index,imode,comment,slides.
1132 use      eex00,ck1
1133 use      ck2
1134 use      ck3
1135 use      ck4
1136 use      ck5
1137 use      ck6
     ckc               not found                      104     466
     ckcw              not found                      866     967
     ckc2w             not found                      107     469
     ckd               not found                      858     964
     ckdw              not found                      136    1028     1063
     ckd1w             not found                      861     988
     endunit   x07end              1126                20    1120
     imode             not found                       31    1112
     jmpmes            not found                     1121
     leave     x07end              1123              1128
     x07end    x07end              1110               632    1113
     x07m0a    eex07id               29                32      51
     x07m1a    x07m1a                49                79     411
     x07m1b    x07m1a                78                52      99      100      110
     x07m1b1   x07m1a                98                80
     x07m1c    x07m1a               109               105     123
     x07m1d    x07m1d               122               134     140
     x07m1d1   x07m1d               133               124
     x07m[illegible]e    x07m1d               139               137     173
     x07m2a    x07m1d               172               186
     x0[illegible]b    x07m2b               185               208     411
     x07m2c    x07m2b               206               187     223      327      856  1064  864
     x07m2d    x07m2b               220               251     867
     x07m2e    x07m2e               248               224     272      324
     x07m2f    x07m2e               270               252
     x07m2f1   x07m2e               291               281
     x07m2f2   x07m2e               304               296
     x07m3a    x07m2e               321               222     339      350
     x07m3b    x07m3b               337               325     354      970      974  990   984
     x07m3c    x07m3b               352               371     411      968
     x07m3c1   x07m3b               360               372
     x07m3d    x07m3b               368               353     411
     x07m3d1   x07s3b              1002              1007
     x07m3d2   x07s3b              1008              1004
     x07m3e    x07m3b               396                52     353      370      870
     x07m4a    x07m4a               413               411     411      436     1107        1111
     x07m4b    x07m4a               435               433    1108
     x07m4c    x07m4a               454               452     456      467      474
     x07m4c1   x07m4a               464               457
     x07m4d    x07m4a               471               467     490
     x07m4e    x07m4e               488               475     534     1033     1050        1064
     x07m4e1   x07m4e               520               507
     x07m4f    x07m4e               532               491     578
     x07m4f1   x07m4e               562               552
```

```
x07m4g    x07m4g         576              535     631
x07m4g1   x07m4g         613              598
x07m4h    x07m4g         629              579
x07s1a    x07s1a         651              101     326
x07s1b    x07s1b         744              111     581
x07s2a    x07s2a         855              207
x07s2a1   x07s2a         863              859
x07s2b    x07s2a         869              187     225    1052
x07s2c    x07s2a         891              253     880
x07s2d    x07s2a         901              254     261     273
x07s2e    x07s2a         912              263     266     274         493
x07s2f    x07s2a         923              268
x07s3a    x07s2a         930              349     365     983
x07s3b    x07s3b         947              366     944
x07s3c    x07s3b         962              340     350
x07s3d    x07s3b         972              965
x07s3e    x07s3b         986              975     984
x07s3f    x07s3b         992              392
x07s4b    x07s3b        1016              476    1029
x07s4c    x07s3b        1032             1030
x07s4d    x07end        1049              492    1059
x07s4d1   x07end        1057             1051
x07s4e    x07end        1066              168     244     483   565   523   610   553
                                         1044
x07s4f    x07end        1091              580
x07s4g    x07end        1106
abs                      933    1004
ahelp                   1129
atime                   1130
cos                      537     934
nc                      1116    1116     1117    1117    1129        1129
n2                      1114    1115     1127    1128
n21                     1116    1116     1117    1117    1129        1129  1130  1130
n33                      103     106      135     465     468   865   857   963   860
                         966     967     1027    1062
n47                       32     105      137     467     859   968   867  1024   965
                        1030    1064     1113
n51                      249     280      281     290     295   348   296   349   303
                         350     982      983     984
n52                      338     373      944
n55                       33      52      187     353     410         411         870
n59                      472     504      506     507     519   561   551   597   552
                         598     612
n99                       24      34      222     326     327         335
sin                      536     898      899     934    1003
sqrt                     941     942      943
vc                      1130    1130
v100                    1082    1086
v101                    1000    1005     1006
v102                     394     999     1003    1005    1005  1009  1006  1011  1009
v103                    1001    1005     1006
v109                     996    1003
v110                    1003    1004     1005
v120                     382     997
v121                     385     997
v140                     942     942      942     943     943         943
v141                     931     932      932     933     933   934   934   941   934
```

```
                 941      941      941      942      943
v141sqr          941
v142             941      942      943
v50              485      540      556      568      569      636      1046
v51              525      540      547      549      636
v51°            536      537
v52              536      547      568      569
v53              537      545      556
v54              551      555      639
v55              567      639
v56              597      600      642
v57              620      642
v60              232      246      506      516      526      527
v61              239      246      504      509      526      527
v70              898      898      899      899
%                394      486      556      568      569  625  621  497  622
                1037     1047
A                957
B                958
-                883      884      885      886
|                892
°                932      933      999     1000     1001
π                882      883      884      885      886  597  894  598  897
                 898      899      899      899     1009
```

lesson information

lesson name = eex07

starting date = 04/11/73

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by neal of course eecge

at site 17, station 18

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discipline = EE

grade level = Freshman

descripion of lesson = Measurements of Impedance.

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                        lesson eex08 at 10:39 pm on wednesday, august 28, 1974
--------------------------------------------------------------- part=1, block=a ---------


          block 1a,    eex08id

  stop
  ****     For Neal, CGERL, Room 248, EEB.

  One line description of this lesson --

     Measurements of Two-Port Networks.

               Divisions of this Lesson:          Block    Unit

             Id for this file                     eex08id
             Experiment eex08:
               Objectives                          x08m0a   x08m0a
               Definition of two-port network      x08m1a   x08m1a
               Voltage gain of a two-port          x08m2a   x08m2a
               Frequency response of two-port      x08m3a   x08m3a
               Final test                          x08m4a   x08m4a

             final edit 21 aug 74 neal.

  *list   info
  *list   symbols
  *list   varian,charset,cgeindex,cgechar
  ****
  start
  finish  endunit
  write   (at,1010) Loading the CGE Character Set
  charset cgeindex,cgechar
  erase
  dataon
  area    eex08
  ext     0
---------------------------------------------------------------- part=1, block=b ---------


          block 1b,    x08m0a


  unit    x08m0a
  next    x08m1a
  define  x08def
          err=n50
          errmess=n51
          it=n52          $$ specifies input terminal of two port
          ot=n53          $$ specifies output terminal of two port
          fc=v55
          fo=v56
  zero    err
```

```
restart
join     imode
jump     n47,x08m0a,x
at       417
write    MEASUREMENTS OF TWO-PORT NETWORKS
at       705
write       When you have completed this experiment, you should
         be able to:

            1. Understand the definition of a two-port network.

            2. Measure the voltage-gain transfer function of a
         two-port network.

            3. Measure the frequency response of the voltage
         gain of a two-port network.

            4. As a final test, measure the frequency response
         of the voltage gain of a band-pass filter.
--------------------------------------------------------------- part=1, block=c -----------


      block 1c,    x08m1a


unit     x08m1a
back     x08m0a
next     x08m1b
at       307
write       Throughout this lesson we will represent a network
         by a box which may be thought of as containing the
         network.

            Leads brought out of the box indicate that
         certain terminals or nodes of the network are
         externally accessible.  That is, we can connect to
         or measure between these terminals or nodes.
draw     1723;1742;2342;2323;1723;2123;2117;skip;1923;1917
         skip;1942;1948;skip;2142;2148;skip;2335;2735
         skip;2730;2330
at       219,187
write     NETWORK
circle   3,128,208
circle   3,128,176
circle   3,376,176
circle   3,376,208
circle   3,232,80
circle   3,272,80
vector   252,41:272,80
vector   252,41:232,80
at       208,21
write     TERMINALS
***

unit     x08m1b
```

```
term    m1b
back    x08m1a
next    x08m1c
at      307
write      A pair of terminals is called a port. A two-port
        network is, therefore, a network with two pairs of
        external terminals.

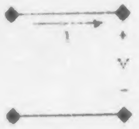
           In a two-port network, one of the ports is usually
        connected to a source, and the other port is usually
        connected to a load.

           For the arrangement shown below, the following
        four electrical quantities can be measured:

                          I1,V1,I2, & V2.
join    x08s1a
join    x08s1b
join    x08s1c
at      2705
write      Throughout this experiment, we will assume that the
        impedance ZL is a very high impedance, i.e., that the
        magnitude of I2 is small compared to the magnitude of I1.
----------------------------------------------------------- part=1, block=d ---------


        block 1d,   x08m1c


unit    x08m1c
back    x08m1b
next    x08m1d
at      307
write      Consider any port, or pair of terminals, in a network
        driven by a single-frequency sinusoidal power source.
        Conventions used here for the voltage and current are:
```



```
           When displayed on the SCOPE, the convenient measures
        of a voltage are Vpp and the time angle φv after t = 0,
        where the voltage is positive-going through v = 0.

           Then, the voltage is expressed mathematically by:

        v (t) = 0.5Vpp sin (ωt + φv) = V0p sin (ωt + φv)

           Here, this voltage is expressed as a phasor by:

        V = |V| ∠φv where |V| = 0.707 Vpp.
```

```
           Similarly, the current representations are:

        i (t) = I0p sin (ωt + øi), I = |I| ∠øi, |I| = 0.707 Ipp.
***

unit    x08m1d
back    x08m1c
next    x08m2a
at      505
write      A transfer function is a relation between two
        activities at two different ports in a network.  This
        contrasts with an impedance function which is a relation
        between two activities at the same port in a network.

           The transfer function called the voltage gain is
        of interest in this experiment.  We will refer to it
        hereafter simply as the gain G and define it by:

         G = |G| ∠øG = V2 / V1 = (|V2|  / |V1|) ∠(øV2 - øV1)

           The gain is a complex quantity and can also be
        written in complex form, like we did for impedances
        in the impedance experiment, as:

                      G = Gre + j Gim
------------------------------------------------------------------- part=1, block=e -----------


       block 1e,   x08m2a


unit    x08m2a
back    x08m1d
next    x08m2b
at      405
write       Now consider the two-port shown below, where port 1
        is the driven port, and port 2 is the load port.

           If V1 = 15 V dc and V2 = 3 V dc,, what is the gain G ?
join    x08s1a
join    x08s1c
join    x08s1b
arrow   926
at      926
write     ___
ansv    .20,.05
wrong   3
at      1111
write   No, the gain of the two port is defined as the
        ratio V2/V1.
***

unit    x08m2b
back    x08m2a
next    x08m2c
```

```
help     x08s2a
at       305
write      Now suppose you are given another two-port network.

                V1pp = 10 ∠0° V drives port 1.

                V2 is then measured as V2pp = 5 ∠+31°.

            What is the voltage gain G of the two-port in polar form,
         i.e., in the form |G|/α°. (Press -MICRO- then o for °.)
join     x08s1a
join     x08s1c
join     x08s1b
at       1210
write    Magnitude ____   Phase angle ____
at       3122
write    -HELP- is available.
arrow    1220
ansv     .5
arrow    1240
answer   <degrees,deg,°>31
wrong    <degrees,deg,°>-31
***

unit     x08m2c
back     x08m2b
next     x08m2d
help     x08s2b
at       405
write      Consider the resistive two port network shown below.

           If V1 = 10 V dc, what is V2 and G.

           V2 =
at       817
write    _____ V dc.
at       830
write    G = _____
join     x08s1d
join     x08s1a
join     x08s1c
at       3122
write    HELP is available
arrow    817
ansv     5
no
at       1005
write      Hint: Think of the two-port network as a simple
          voltage divider. Note also that -HELP- is available.
arrow    833
ansv     .5
no
at       1011
write    You got V2 correct, now simply use the formula
         G = V2/V1 to find the voltage gain.
------------------------------------------------------------- part=1, block=f ----------
```

```
    block 1f,    x08m2d

unit      x08m2d
back      x08m2c
next      x08m2e
calc      it⇐1
          ct⇐3
at        405
write        Let's try to verify this last result experimentally.
          The resistive two-port just studied is part of the
          the superposition circuit.  Plug in the sensor cable
          of the SUPERPOSITION BOARD, ITEM 38, and place all
          the switches on the board (SW1 through SW4) in the
          up position.

             You should now have the following two-port network:
join      x08s1a
join      x08s1b
join      x08s1c
at        1817
write     1
at        1843
write     2
at        2316
write     11
at        2347
write     11
pause
at        2320
write     1
at        2705
write        In this experiment, terminal 1, is used as the
          common grounded terminal.
***

unit      x08m2e
back      x08m2d
next      x08m2f
calc      errmess⇐0
zero      err
join      x08s2h
end
***

unit      x08m2f
pack      n33,+++efhe++a+++a(abcd)+aaa++1
join      ckd
jump      n47,x08s2c,x

entry     x08m2g
pack      n33,aacdd0cc00k0k00ac000000000akc0
join      ckc
calc      errmess⇐0
```

```
             err⇐n47
      jump   n47,x08s2d,x08m2h
      ***

      unit   x08m2h
      erase
      catchup
      back   x08m2d
      next   x08m2j
      zero   err
      at     405
      write     Measure the gain of the two-port by setting  the
             following dials:

                1) Set the OSCILLOSCOPE to display a 1 kHz sine
             wave with an amplitude in the range 5 ≤ Vpp ≤ 10 V.
             Set the Y DISPLAY to A, the A PRE AMP to +AC,
             the TRIGGER SOURCE to AC INT, and the SWEEP MODE to
             AUTO.

                2) Set the RANGE control of the VACUUM TUBE VOLTMETER
             to 3 RMS VOLTS.

                3) Adjust the frequency controls of the AUDIO
             OSCILLATOR to produce a 1 kHz sine wave output.
             Temporarily connect the VTVM INPUT to terminal
             ‹z,it› of the two-port network and then
             adjust the AMPLITUDE dial of the AUDIO
             OSCILLATOR to give a 2 rms V reading on the VTVM.

                4) Now reconnect the VTVM INPUT to terminal ‹z,ot› of
             the two-port network.
      end
      join   x08m2i
      ***

      unit   x08m2i
      at     2805
      write     After setting these dials, press -NEXT-.
      ***

      unit   x08m2j
      pack   n33,+(gh)mecfbab+++++++++(bc)b(pq)h
      join   ckd
      calc   errmess⇐0
             err⇐n47
      jump   n47,x08s2f,x08m2k
 ------------------------------------------------------------- part=1, block=g ----------


          block 1g,    x08m2k


      unit   x08m2k
      back   x08m2h
```

```
next    x08m2l
at      405
write      You have now correctly set up the two-port network
        for gain measurements. Without changing the
        AMPLITUDE dial of the AUDIO OSCILLATOR at all,
        measure the output port voltage (terminal 3) on the VTVM.

           What is value that you read on the VTVM?

arrow   1110
at      1110
write      ____ rms V
store   v52
ansv    1,5%
at      1605
write      The input voltage V1 to the two-port network was
        set above to 2 rms V.

           The output voltage V2 that you obtained was
        <s,v52> rms V.

           What is the voltage gain of the two port?
arrow   2417
ansv    v52/2,5%
wrongv  2/v52,5%
at      2605
write      Remember the voltage gain of a two-port is defined
        as V2/V1, not V1/V2!!!
no
at      2605
write      You have miscalculated the voltage gain G.
        Check again to make sure that V1 is 2 rms V.
        and remeasure the output port voltage, V2.
***

unit    x08m2l
erase
catchup
back    x08m2k
next    x08m2n
at      805
write      Now vary the frequency of the AUDIO OSCILLATOR, making
        sure to keep the input voltage V1 constant as you do this.


entry   x08m2m
at      1205
write      It may be helpful to first set V1 to 2 rms V, at a
        particular frequency (e.g. 1 kHz). Then, with A VOLTS
        FULL SCALE set to 5 V, take the A PRE AMP off of
        calibration. This is done by rotating the red knob
        marked VARIABLE GAIN counter-clockwise.

           By adjusting the VARIABLE GAIN, set the peak-to-peak
        deflection on the SCOPE to exactly 10 divisions and leave
        it there.
```

```
             Thereafter, as you rotate the frequency dial of the
          AUDIO OSCILLATOR, readjust only the AUDIO OSCILLATOR
          AMPLITUDE control to maintain a constant peak-to-peak
          deflection on the SCOPE.
    end
------------------------------------------------------------- part=1, block=h ----------


       block 1h,   x08m2n


    unit     x08m2n
    back     x08m2l
    next     x08m2o
    lab      x08m2m
    at       805
    write       Do you notice any change in the amplitude of the
             output voltage  on the VTVM, as the input frequency
             to the two-port is varied?
    arrow    1220
    answer   (n,no,N,No)
    at       1405
    write       Right! As long as the input amplitude to a resistive
             two-port is held constant, the output voltage
             amplitude will not vary as a function of frequency.
             This is because the impedance of a resistor is
             independent of frequency and hence the voltage
             gain of a resistive two-port is independent of
             frequency.
    wrong    (y,yes,Y,Yes,some)
    at       1405
    write       Make sure that you keep the input voltage
             to the two-port constant as you vary the frequency.
             Press -LAB- if you need a hint on how to do this.
    ***

    unit     x08m2o
    at       805
    write       If you have taken the A VOLTS off of calibration
             by adjusting the red VARIABLE GAIN knob, place
             the A VOLTS back into calibration by rotating
             the red VARIABLE GAIN dial fully clockwise until
             it clicks.

                When the A channel is in its calibrated mode,
             the A VOLTS window will be lit.
    pause

    entry    x08m2p
    join     imode
    jump     n47,x08m2p,x08m3a
------------------------------------------------------------- part=1, block=i ----------
```

```
        block 1i,    x08m3a


unit      x08m3a
back      x08m2n
next      x08m3b
base
at        405
write        Plug the sensor cable of the TWO PORT NETWORK BOARD,
          ITEM 36, into the interface.

             In this part of the experiment, the two port
          concerned consists of a series capacitor and a
          shunt resistor. The input port is terminals 1 & 2
          and the output port is terminals 3+ 2. Terminal 2
          will be used as the ground terminal. Locate these
          terminals on the board now.
***

unit      x08m3b
zero      [illegible]
back      x08m3a
next      x08m3c
join      x08s2h
end

------------------------------------------------------------------- part=1, block=j -----------


        block 1j,    x08m3c


unit      x08m3c
pack      n32,abc00000000b00ac00000000abc0
join      ckc
calc      errmess⇐1
          err⇐n47
jump      n47,x08s2d,x08m3d
***

unit      x08m3d
back      x08m3a
next      x08m3e
data      x08m2h
[illegible] [illegible]
          [illegible]
at        405
write        Set the equipment dials to the same positions
          you previously used for measuring the gain of the
          resistive two port.

             Press -DATA- to review the dial settings necessary

                                 OR
```

```
                 Press -NEXT- after you have properly set the dials.
***

unit      x08m3e
pack      n33,++m+cfoab+++++++++bb(pq)h
join      ckd
calc      errmess⇐1
          err⇐n47
jump      n47,x08s2f,x08m3f
***

unit      x08m3f
back      x08m3d
next      x08m3g
data      x08m2m
at        405
write        Now, monitoring the output port with the VTVM,
          vary the AUDIO OSCILLATOR frequency over the range
          of 20 Hz to 100 Hz, while keeping the voltage
          amplitude at the input port constant.
at        905
write        Press -DATA- for a hint on keeping the input
          port voltage amplitude constant.
at        1405
write        Does the output voltage vary as a function of
          frequency?
arrow     1524
answer    (y,Y,yes,Yes)
at        1705
write        Right! If the input port voltage V1 is held
          constant, the output port voltage V2 will vary as
          a function of frequency.

             Our next goal will be to predict the frequency response
          of the gain of a simple two-port RC network.

             Leave your equipment setup alone, as it will be
          used later.
wrong     (n,N,no,No)
at        1710
write        Make sure that you are keeping the input
          port voltage constant and that you are varying
          the AUDIO OSCILLATOR over the correct frequency
          range.
***

unit      x08m3g
back      x08m3f
next      x08m3h
lab       x08s2b
at        405
write        The gain G of the two port you have just connected
          may be analyzed easily by using the voltage-divider
          concept, where impedances are used instead of resistances.

             When I2 is negligible with respect to I1, the gain
          of the two-port under study is approximated by:
                G(jω)  =  V1  =  __jωRC__
                          V2     1 + jωRC

            where R = 2 kΩ, C = 1 µF, and ω = 2πf.

               Note that the gain is now a function of frequency,
            and may be designated by G(jω).

               To review the voltage divider concept, press -LAB-.


               We will now measure G(jω) as a function of frequency.
----------------------------------------------------------------- part=1, block=k ----------


        block 1k,    x08m3h


      unit      x08m3h
      back      x08m3g
      next      x08m3i
      at        405
      write        The magnitude of G(jω) in deciBels (abbreviated dB)
            is defined by |G(jω)|dB = 20 × log10 |G(jω)|  dB

               The advantage of using the deciBel or logarithmic
            notation is that it permits the easy computation
            of the magnitude of a product of gain functions, by
            simply adding the individual deciBel values, i.e.:

            |G1(jω)G2(jω)|dB = |G1(jω)|dB + |G2(jω)|dB

               It may also be noted that the phase angle of the
            product of two gains is simply the sum of their angles:

            ∠G1(jω)G2(jω) = ∠G1(jω) + ∠G2(jω)

               The measurement of |G|dB is facilitated by the
            use of the VTVM's dB scale. The use of this scale
            in measuring |G|dB will be covered next.
      ***

      unit      x08m3i
      back      x08m3h
      next      x08m3j
      at        204
      write             USE OF THE dB SCALE ON THE HP400D VTVM

               A deciBel is defined as 20 log10 a/b, i.e., 20 times
            the log to the base 10 of the ratio of two numbers.

               For our use (finding the gain of a two-port), the
            dB scale on the VTVM makes gain measurements easy.
```

The dB scale on the VTVM is calibrated in terms of the ratio of the measured voltage V_x to the reference voltage. The reference voltage used on the VTVM is V_r = 0.775 rms V. Hence, the dB reading on the VTVM of any voltage is

$$|V_x|_{dB} = 20 \log_{10} |V_x/V_r| = 20 \log_{10} |V_x| - 20 \log_{10} |0.775|$$

In making a gain measurement, it is convenient to set the VTVM to the proper voltage scale to read $|V_2|$, but before reading it, readjust V_1 so the pointer indicates 0 dB on the dB scale. Then the value of $|V_2|_{dB}$ is that value , 0 dB, plus the label on the RANGE dial setting.

Next, without further adjusting V_1, measure V_1 on the dB scale, adjusting the RANGE switch so as to give the most accurate reading. Then, $|V_1|_{dB}$ is the sum of the dB scale reading and the dB RANGE label. Finally

$$|V_2/V_1|_{dB} = |V_2|_{dB} - |V_1|_{dB}$$

```
end
```

--- part=1, block=1 ---------

block 11,   x08m3j

```
unit     x08m3j
base
back     x08m3i
next     x08m3k
lab      x08m2m
at       405
write
```

Now measure the frequency response of $|G|_{dB}$:

1) At 5 kHz, adjust the A.O. AMPLITUDE dial so that the VTVM, which is currently displaying V_2, reads '0 dB', when the RANGE dial is set to +10 dB.

2) Now keeping V_1 constant, decrease the frequency of the A.O. until the gain is down 3 dB from its 5 kHz value.

Press -LAB- for a suggestion on keeping V_1 constant.

At what frequency is the gain down 3 dB?   Hz

```
arrow    1649
store    fc
ansv     66.5,5%
*wrong
at       1805
write
```

The frequency at which $|G|_{dB}$ is down 3 dB from its high frequency value is known as the corner frequency, f_o, of the two port.

```
***
```

```
unit     x08m3k
back     x08m3j
at       410
write     Measure |G|_dB at .5,.7,1,2,3,5,& 10 times f_o.

               FREQUENCY (Hz)                 |G|_dB

         .5×f_o =◂e,.5×f_c▸   Hz

         .7×f_o =◂e,.7×f_c▸   Hz

          1×f_o =◂e,1×f_c▸  Hz

          3×f_o =◂e,3×f_c▸  Hz

          5×f_o =◂e,5×f_c▸  Hz

         10×f_o =◂e,10×f_c▸   Hz
calc     n60⇐640
         n61⇐61

entry    x08m3l
calc     n61⇐n61+1
calcs     (n61-63),v70⇐-6.5,-4.7,-3,-.5,-.3,0
arrow     (n60⇐n60+200)
store     v(n61)
ansv     v70,.3
endarrow
inhibit erase
goto      (n61>66),x08m3m,x08m3l
***

unit     x08m3m
next     x08m3n
back     x08m3k
at       2105
write       To make evaluation of your data more meaningful,
         the data above will be plotted when you press -NEXT-.
***

unit     x08m3n
back     x08m3k
erase
origin   100,100
axes     300,300
lscalex 10000,10
scaley   0,-10
markx    20,10,2
labely   2,1,0
gdraw    (.5×f_c),v62;(.7×f_c),v63;f_c,v64;(2×f_c),v65;(3×f_c),v66;(5×f_c),v67;(10×f_c),v68
write    ◂at,2713▸10^1           10^2    Hz     10^3          10^4
write    ◂at,1606▸dB
at       205
write       The graph below is known as a Bode plot of the
         gain. Note that the vertical scale is a linear plot
         of logarithmic values, and the horizontal scale is
         a logarithmic plot of frequency values.
```

```
at        2805
write        Note also that at low frequencies (below fo). the
          gain is low, while at high frequencies, the gain is
          approaching unity (0 dB = 1). Hence, this two port
          network is called a high-pass filter.

------------------------------------------------------------------ part=1, block=m ---------


     block 1m,    x08m3o


unit      x08m3o
back      x08m3k
next      x08m3p
at        405
write        We will now measure the frequency response of the
          voltage gain for another type of two port network.

             Leave the two port network board plugged in, but
          remove all connections to the board and to the
          instruments.
pause
pack      n33,a0a00000000b0000000000000b00
join      ckc
jump      n47,x08m3o,x08m3p
***

unit      x08m3p
back      x08m3o
next      x08m3q
lab       x08s2h
zero      err
at        405
write        The next two port network to be studied consists
          of terminals 4,5, & 2 on the TWO PORT NETWORK BOARD.

             The input port is between terminals 4+ 2, and the
          output port is between terminals 5 & 2, with the common
          terminal 2 used as the ground terminal.

             Make the necessary connections to this two port to
          enable you to measure |G|dB as a function of frequency.

             These connections are the same as those used for
          the last 2 two-ports. Press -LAB- to review the
          necessary connections.
end
***

unit      x08m3q
pack      n33,0a0bc0000000a00bc000000000bac0
join      ckc
calc      errmess⇐2
          err⇐n47
jump      n47,x08s2d,x08m3r
```

```
-------------------------------------------------------------- part=1, block=n ----------

          block 1n,    x08m3r

      unit    x08m3r
      back    x08m3p
      next    x08m3s
      data    x08m2h
      calc    it⇐4
              ot⇐5
      at      405
      write      Set the dials on the equipment to measure |G|dB
              of this two port network. Use the same dial settings
              that you used to measure |G|dB of the high pass filter.

                 Press -DATA- to review the needed dial settings.
      ***

      unit    x08m3s
      pack    n33,++m+cfbab+++++++++bb(pq)h
      join    ckd
      calc    errmess⇐2
              err⇐n47
      jump    n47,x08s2f,x08m3t
      ***

      unit    x08m3t
      back    x08m3r
      next    x08m3u
      lab     x08m21
      at      405
      write      Now measure the frequency response of |G|dB as follows:

              1) At 100 Hz, adjust the A.O. AMPLITUDE dial so that
              the VTVM (which is currently displaying V2) reads 0 dB,
              when the RANGE dial is set to the +10 dB scale.

              2) Now keeping V1 constant, increase the frequency of the
              A.O. until the gain is down 3 dB from its 100 Hz value.

                 Press -LAB- for a suggestion on keeping V1 constant.

                 At what frequency is the gain down 3 dB?          Hz.
      arrow   1549
      store   fo
      ansv    1820,3%
      *wrong
      at      1805
      write      The frequency at which |G|dB is down 3 dB from its
              low frequency value is known as the corner frequency
              fo of this network.

-------------------------------------------------------------- part=2, block=a ----------
```

block 2a,   x08m3u

```
unit     x08m3u
back     x08m3t
lab      x08m3l
base
at       403
write       Measure |G|dB of this two port as indicated below.

            Press -LAB- to review the measurement procedure.
at       810
write       FREQUENCY                          |G|dB

         .1×fo =‹e,.1×fo›   Hz

         .2×fo =‹e,.2×fo›   Hz

         .5×fo =‹e,.5×fo›   Hz

         .7×fo =‹e,.7×fo›   Hz

          1×fo =‹e,1×fo›   Hz

          2×fo =‹e,2×fo›   Hz

          3×fo =‹e,3×fo›   Hz

          5×fo =‹e,5×fo›   Hz

         10×fo =‹e,10×fo›   Hz
calc     n60⇐840
         n61⇐99

entry    x08m3v
calc     n61⇐n61+1
calcs    (n61-101),v70⇐0,-.2,-1,-1.9,-3,-7.2,-10.1,-14,-20
arrow    (n60⇐n60+200)
store    v(n61)
ansv     v70,.3
no
endarrow
inhibit erase
goto     (n61>107),x08m3w,x08m3v
***

unit     x08m3w
back     x08m3u
next     x08m3x
at       2805
write       To make evaluation of your data more meaningful,
         the data above will be plotted when you press -NEXT-.
***
```

```
unit     x08m3x
back     x08m3u
next     x08m4a
erase
origin   100,100
axes     300,300
lscalex  100000,100
scaley   0,-25
markx    20,10,2
labely   5,1.0
gdraw    (.1×f_o),v100;(.2×f_o),v101;(.5×f_o),v102;(.7×f_o),v103;f_o,v104
gdraw    f_o,v104;(2×f_o),v105;(3×f_o),v106;(5×f_o),v107;(10×f_o),v108
write    <at,2713>10^2          10^3     Hz     10^4          10^5
write    <at,1606>dB
at       205
write       The graph below is the Bode plot of |G|_dB for the two
         port network you currently have set up.

            Note that the plot differs from the Bode plot of the
         high-pass filter previously studied.
at       2805
write         Since low frequencies are passed and high frequencies
         are attenuated, this two port network is known as
         a low-pass filter.
```

-- part=2, block=b ----------

```
      block 2b,   x08m4a


unit     x08m4a
restart
base
back     x08m3x
next     x08m4b
erase
catchup
at       405
write       The great utility of the Bode-plot method of
         recording G vs f is easily demonstrated.

            Consider the two gains you have evaluated experimentally
         for the high-pass and low-pass filters. The gain for
         a filter consisting of those two filters cascaded is
         simply the product of the gains of the individual filters.

            The 2 two-ports are cascaded simply by connecting
         Terminal 3 to Terminal 4. The input port is then Terminals
         1 & 2, and the output port is Terminals 5 & 2.  Note
         that Terminal 2 is the common ground terminal.

            The gain |G|_dB of this composite filter, using
         your calculated values, is shown in the next display.
***
```

```
unit      x08m4b
origin    75,100
axes      350,300
lscalex   1000000,10
scaley    0,-25
markx     20,10,2
labely    5,1,0
write     <at,2709>10^1           10^2          10^3          10^4          10^5
write     <at,28,241>|G|_dB
write     <at,2831>f  (Hz)
gdraw     (.5×f_c),v62; (.7×f_c),v63; f_c,v64; (2×f_c),v65; (3×f_c), (v66+v100);
gdraw     (3×f_c), (v66+v100); (5×f_c), (v67+v101); (10×f_c),v68
gdraw     (10×f_c),v68; (.5×f_o),v102; (.7×f_o),v103; f_o,v104; (2×f_o),v105; (3×f_o),v106;
gdraw     (3×f_o),v106; (5×f_o),v107; (10×f_o),v108
------------------------------------------------------------------------------------ part=2, block=c ---------

        block 2c,   x08m4c

unit      x08m4c
base
back      x08m4a
data      x08m2h
lab       x08m2i
help      x08m2l
calc      it⇐1
          ot⇐5
at        405
write        Check the preceding display experimentally, by measuring
          and entering |G|_dB in the table below:

                FREQUENCY                        |G|_dB

                   50 Hz

                  100 Hz

                  200 Hz

                  500 Hz

                    1 kHz

                    2 kHz

                    5 kHz

                   10 kHz

                   15 kHz
at        2808
write     Press -DATA- to review the dial settings.
                -LAB- to review the connections.
```

```
                       -BACK- for the terminal numbers of the two-port.
                       -HELP- for a hint on keeping V1 constant.
calc      n60⇐839
          n61⇐110

entry     x08m4d
calc      n61⇐n61+1
calcs     (n61-112),v70⇐-4.3,-1.8,-.75,-.6,-1.3,-3.8,-9.5,-15,-18.2
arrow     (n60⇐n60+200)
store     v(n61)
ansv      v70,.5
no
endarrow
inhibit erase
goto      (n61>118),x08m4e,x08m4d
***

unit      x08m4e
next      x08m4f
mode      rewrite
at        2805                $$ blank lines needed for rewrite
write        Press -NEXT- to see your experimental values
          superimposed as *'s on the calculated Bode plot.


***

unit      x08m4f
erase
origin    75,100
axes      350,300
lscalex   1000000,10
scaley    0,-25
markx     20,10,2
labely    5,1,0
write     ‹at,2709›10^1         10^2        10^3        10^4        10^5
write     ‹at,28,241›|G|dB
write     ‹at,2831›f (Hz)
gdraw     (.5×fc),v62;(.7×fc),v63;fc,v64;(2×fc),v65;(3×fc),(v66+v100);
gdraw     (3×fc),(v66+v100);(5×fc),(v67+v101);(10×fc),v68
gdraw     (10×fc),v68;(.5×fo),v102;(.7×fo),v103;fo,v104
gdraw     fo,v104;(2×fo),v105;(3×fo),v106;(5×fo),v107
gdraw     (5×fo),v107;(10×fo),v108
graph     50,v111,*
graph     100,v112,*
graph     200,v113,*
graph     500,v114,*
graph     1000,v115,*
graph     2000,v116,*
graph     5000,v117,*
graph     10000,v118,*
graph     15000,v119,*
at        2905
write        Note that this two port network attenuates frequencies
          greater than 600 Hz and less than 200 Hz. Because of this
          characteristic, this network is known as a band-pass filter.
pause
```

```
jump    x08end

------------------------------------------------------------- part=2, block=d ---------


      block 2d,   x08s1a

unit    x08s1a
draw    1723;1742;2342;2323;1723
draw    1823;1817;skip;2223;2223;2217
circle  3,128,160
circle  3,128,224
at      1917
write   +
at      128,168
write   -
at      128,188
write   V1
at      1719
write   I1
at      1819
write   →
draw    1842;1848
circle  3,376,224
at      373,207
write   +
draw    2242;2248
circle  3,376,160
at      375,171
write   -
at      372,184
write   V2
at      348,224
write   →
at      348,240
write   I2
***

unit    x08s1b
draw    1848;426,224
at      423,208
write   |
        >
        >
        |
draw    426,160;2248
at      440,188
write   ZL
***

unit    x08s1c
draw    1817;1811
circle  16,80,192
draw    1911;1811;skip;2111;2211;2217
at      76,192
```

```
write   +
        -
***

unit    x08s1d
at      200,220
write   -^v-
draw    1830;1834
at      261,208
write   |
        >
        <
draw    2223;2242;2234;2134;skip;1834;1834;1842;skip;1826;1823
at      192,203
write   3300Ω
at      272,188
write   3300Ω
***

unit    x08s2a
at      505
write      Complex numbers may be written in two forms;

        rectangular form (A+jB) and polar form (|C|∠α°).

           The two forms are interrelated by the following
        equations:

at      1010
write
              |C| = $\sqrt{A^2 + B^2}$

               α = $\tan^{-1}$(B/A)
at      1135
write   A=|C|cos α

        B=|C|sin α
at      1605
write      To divide two complex numbers, first put both
        numbers into polar form. Then divide the magnitudes
        and subtract the phase angles.

             For example: $\frac{A\angle\alpha}{B\angle\beta} = \frac{A}{B}\angle(\alpha - \beta)$

end
```

```
---------------------------------------------------------------- part=2, block=e --------
```

```
     block 2e,    x08s2b

unit    x08s2b
at      405
write      The network below is known as a voltage divider network,
        when I2 is negligible with respect to I1:
```

```
at       192,380
write    -^v^-
          R1
at       735
write       I2
         ------->
at       1034
write    >
         <
draw     820;825;skip;829;267,384;267,368;skip;267,384
         842;skip;1220;1242;skip;267,335;267,320
at       280,348
write    R2
at       152,346
write    V1
at       320,346
write    V2
at       920
write    +
at       152,326
write    -
at       318,327
write    -
at       318,368
write    +
draw     1023;1031;1131;1126;204,340;skip;204,332;200,336
at       1124
write    I1
at       1405
write       From the above network, the following equations
         can be derived:
at       1626
write    1) V2 = R2I1

         2) I1 = V1/(R1 + R2)
at       2005
write       Substituting eq. 1) into eq. 2), the following equation
         is obtained:               R2V1
                              V2 = -----
                                    R1+R2

            The output voltage V2 is just that part of the input
         voltage V1 appearing across R2. Hence the name 'voltage
         divider'.

            It can be shown that this voltage divider idea holds
         in general for impedances Z1 and Z2 in place of R1 and
         R2, and also holds for ac voltages.
end
***

unit     x08s2c
next     x08m2f
at       405
write       At this point, you have not yet been asked to set
         any dials. Set all dials back to their initial mode
         positions, and then press -NEXT- to proceed.
***
```

```
unit    x08s2d
help    errmess,x,x08m2e,x08m3b,x08m3p
next    errmess,x,x08m2g,x08m3c,x08m3q
join    (err<0),x08s2e,x
at      605
write      Press -NEXT- if you know and have corrected your error.

        or, press -HELP- to review the needed connections.
***

unit    x08s2e
at      408
write   There is something wrong with your connections.
```

```
------------------------------------------------------------------------- part=2, block=f --------
```

```
     block 2f,   x08s2f


unit    x08s2f
next    errmess,x,x08m2i,x08m3e,x08m3s
help    x08m2h
join    (err<0),x08s2g,x
at      1005
write      Press -NEXT- if you know and have corrected your
        errors.

           Press -HELP- if you wish to review the needed dial
        settings.
***

unit    x08s2g
at      810
write   You have incorrectly set <z,-n47> dials(s).
***

unit    x08s2h
at      405
write      Now make the following connections:

        1) Connect the input port of the two port network to
        the AUDIO OSCILLATOR.

        2) Also connect the input port to the A INPUT of the
        OSCILLOSCOPE.

        3) Connect the output port of the two port network
        to the INPUT of the VACUUM TUBE VOLTMETER.

        4) Finally, connect the output port of the two port
        network to the B INPUT of the OSCILLOSCOPE.
at      2105
write      Did you remember to correctly connect all grounds.
```

```
                Press -BACK- to review the terminal numbers of the
           two port under study.
at         2605
write         When you are through making the above connections,
           press -NEXT-.
end

unit       x08s2i
erase
catchup
at         405
write         Now make the following connections:

              1) Connect the input port of the two port network
           to the AUDIO OSCILLATOR.

              2) Also connect the input port to the A INPUT of the
           OSCILLOSCOPE.

              3) Connect the output port of the two port network
           to the INPUT of the VACUUM TUBE VOLTMETER.

              4) Finally, connect the output port of the two port
           network to the B INPUT of the OSCILLOSCOPE.
at         2105
write         Did you remember to correctly connect all grounds.
end
```

--- part=2, block=g ---------

block 2g, x08end

```
unit       x08end
back       x08m3a
join       imode
jump       n47,x08end,x
course     n2
calcc      n2='ee244',
           nc(n21+1)⇐(nc(n21+1)$mask$o77777777770000000000)+o4603000000,
           nc(n21+1)⇐nc(n21+1)
erase
output     /// student has completed experiment ///
join       endunit
join       jmpmes
jumpout    cgeindex,quest1

entry      leave
end        lesson
***

unit       endunit
course     n2
jump       n2≠'ee244',leave,x
calc       nc(n21+7)⇐nc(n21+7)+ahelp
```

```
1098          vc(n21+6)⇐vc(n21+6)+atime/60000
1099   ***Incl.cge s.r. & terms sample,index,imode,comment,slides.
1100   use    eex00,ck1
1101   use    ck2
1102   use    ck3
1103   use    ck4
1104   use    ck5
1105   use    ck6
       ckc           not found                      259     419     627     650
       ckd           not found                      255     297     440     669
       endunit  x08end         1094                  30    1088
       imode         not found                       39     393    1080
       jmpmes        not found                     1089
       leave    x08end         1091                1096
       x08end   x08end         1078                 872    1081
       x08m0a   x08m0a           28                  40      55
       x08m1a   x08m1a           54                  29      83
       x08m1b   x08m1a           81                  56     104
       x08m1c   x08m1c          103                  84     126
       x08m1d   x08m1c          125                 105     143
       x08m2a   x08m2a          142                 127     162
       x08m2b   x08m2a          161                 144     185
       x08m2c   x08m2a          184                 163     215
       x08m2d   x08m2d          214                 186     246     207
       x08m2e   x08m2d          245                 216    1017
       x08m2f   x08m2d          253                 247    1010
       x08m2g   x08m2d          257                1018
       x08m2h   x08m2d          264                 262     303     427     658 1030 797
       x08m2i   x08m2d          291                 289    1029
       x08m2j   x08m2d          295                 268
       x08m2k   x08m2k          302                 300     337
       x08m2l   x08m2k          334                 304     359     677     799
       x08m2m   x08m2k          342                 361     448     543
       x08m2n   x08m2n          358                 338     397
       x08m2o   x08m2n          382                 360
       x08m2p   x08m2n          392                 394
       x08m3a   x08m3a          396                 394     412     425    1079
       x08m3b   x08m3a          410                 398    1017
       x08m3c   x08m3c          417                 413    1018
       x08m3d   x08m3c          424                 422     446
       x08m3e   x08m3c          438                 426    1029
       x08m3f   x08m3c          445                 443     478
       x08m3g   x08m3c          477                 447     496
       x08m3h   x08m3h          495                 479     514
       x08m3i   x08m3h          513                 497     541     698
       x08m3j   x08m3j          539                 515     564
       x08m3k   x08m3j          563                 542     588     594     617
       x08m3l   x08m3j          576                 584
       x08m3m   x08m3j          586                 584
       x08m3n   x08m3j          593                 587
       x08m3o   x08m3o          616                 628     631
       x08m3p   x08m3o          630                 618     628     656    1017
       x08m3q   x08m3o          648                 632    1018
       x08m3r   x08m3r          655                 653     675
       x08m3s   x08m3r          667                 657    1029
       x08m3t   x08m3r          674                 672     697
       x08m3u   x08m3u          696                 676     728     735
```

```
x08m3v    x08m3u      716                 725
x08m3w    x08m3u      727                 725
x08m3x    x08m3u      734                 729      761
x08m4a    x08m4a      758                 736      796
x08m4b    x08m4a      779                 762
x08m4c    x08m4c      794
x08m4d    x08m4c      822                 831
x08m4e    x08m4c      833                 831
x08m4f    x08m4c      842                 834
x08s1a    x08s1a      874                  95      149      171        197        228
x08s1b    x08s1a      904                  96      151      173
x08s1c    x08s1a      915                  97      150      172        198        229
x08s1d    x08s1a      923                 196      227
x08s2a    x08s1a      937                 164
x08s2b    x08s2b      959                 187      480
x08s2c    x08s2b     1009                 256
x08s2d    x08s2b     1016                 262      422      653
x08s2e    x08s2b     1024                1019
x08s2f    x08s2f     1028                 300      443      672
x08s2g    x08s2f     1038                1031
x08s2h    x08s2f     1042                 250      414      633
x08s2i    x08s2f     1061                 798
ahelp       x08def   1097
atime       x08def   1098
err         x08def     31        37       249      261      269 421    299 442    411
                      634       652       671     1019     1031
errmess     x08def     32       248       260      298      420 670    441 1017   651
                     1018      1029
f_c         x08def     35       555       568      569      570 573    571 602    572
                      602       602       602      602      602 784    602 784    789
                      789       789       790      790      790 853    791 853    853
                      853       853       854      854      854        855
f_o         x08def     36       688       705      706      707 710    708 711    709
                      712       713       744      744      744 745    744 745    744
                      745       745       745      791      791 791    791 792    791
                      792       792       855      855      855 856    856 856    856
                      857       857
it          x08def     33       217       283      428      659        800
nc          x08def   1084      1084      1085     1085     1097       1097
n2          x08def   1082      1083      1095     1096
n21         x08def   1084      1084      1085     1085     1097       1097 1098  1098
n33         x08def    254       258       296      418      439        626 668    649
n47         x08def     40       256       261      262      299 421    300 422    394
                      442       443       628      652      653 1040   671 1081   672
n50         x08def     31
n51         x08def     32
n52         x08def     33
n53         x08def     34
n60         x08def    574       579       579      714      719 825    719 825    820
n61         x08def    575       577       577      578      580 717    584 717    715
                      718       720       725      821      823 826    823 831    824
ot          x08def     34       218       286      429      660        801
v           x08def    580       720       826
vc          x08def   1098      1098
v100        x08def    744       789       790      853      854
v101        x08def    744       790       854
v102        x08def    744       791       855
```

```
v103        x08def        744      791      855
v104        x08def        744      745      791      855      856
v105        x08def        745      791      856
v106        x08def        745      791      792      856
v107        x08def        745      792      856      857
v108        x08def        745      792      857
v111        x08def        858
v112        x08def        859
v113        x08def        860
v114        x08def        861
v115        x08def        862
v116        x08def        863
v117        x08def        864
v118        x08def        865
v119        x08def        866
v52         x08def        314      320      323      324
v55         x08def         35
v56         x08def         36
v62         x08def        602      789      853
v63         x08def        602      789      853
v64         x08def        602      789      853
v65         x08def        602      789      853
v66         x08def        602      789      790      853      854
v67         x08def        602      790      854
v68         x08def        602      790      791      854      855
v70         x08def        578      581      718      721      824      827
%           x08def        315      323      324      556      689

                                   lesson information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```